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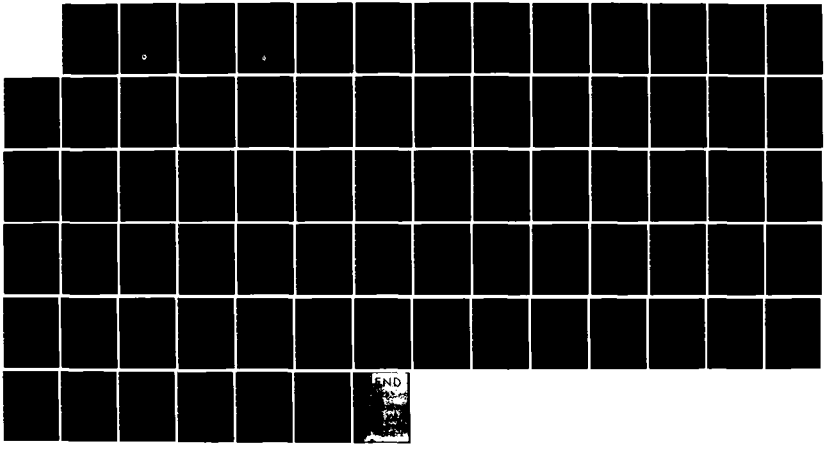

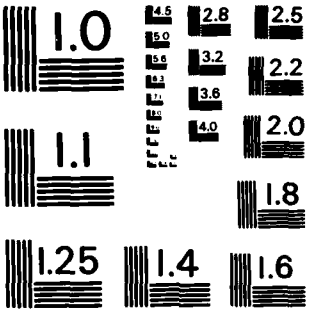

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COMPUTER CONTROL OF THE UNDERWATER ACOUSTIC ARRAY HYDRA

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ABSTRACT

This document describes the software used to control the underwater acoustic array Hydra. The Hydra array was developed at Defence Research Establishment Atlantic (DREA) for bottom mounted use in continental shelf waters. The array is controlled from a minicomputer on board ship, and through a microprocessor in the array. Both the minicomputer software and the microprocessor software are described.

RESUME

Le présent document décrit le logiciel utilisé pour commander le réseau acoustique sous-marin Hydra. Le réseau Hydra a été mis au point au Centre de recherches pour la défense Atlantique (CRDA) pour être installé sur les fonds marins dans les eaux du plateau continental. Le réseau est commandé par un mini-ordinateur à bord d'un bateau et par l'intermédiaire d'un microprocesseur dans le réseau. Le logiciel du mini-ordinateur et le logiciel du microprocesseur sont décrits.

Hydra-array control

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1 Introduction

This document describes the software used to control the Hydra array. The Hydra array is a modular, digital, hydrophone array developed at Defence Research Establishment Atlantic (DREA). Hydra was developed primarily as a bottom mounted array to collect acoustic information in continental shelf waters. It has been used in combined vertical and horizontal configurations in the waters off Nova Scotia, Newfoundland and England over the past five years.

The Hydra array is a rugged array designed for shallow water use. It normally has sensor spacings from 1.5 m to 63 m, and a total length of less than 400 m. The acoustic frequency response of the array is within the range of 1 Hz to 3000 Hz. The mechanical and electrical aspects of this array have already been described by [Staal, Hughes and Olsen, 1981], but a brief background to the array is presented in Section 2.

The Hydra array system includes not only the array itself and directly connected electronics (the "wet-end"), but also the radio link, the shipboard decommutators, the shipborne control and data acquisition computers, and the high-density backup data recorders. In order to provide the flexibility required to follow swiftly varying experimental requirements, this system is very versatile and complex. It became obvious in the early development of the system that a relatively sophisticated software package would be required to control the array, to display its configuration, and to log automatically the highly variable states of the system.

This software package developed for the Hydra system is described in three sections. Firstly, the rationale for the general software design is discussed in Section 3. Secondly, the software for the microprocessor embedded in the wet-end of the Hydra array system is explained in Section 4. Thirdly, the software for a minicomputer on board the ship is described in Section 5. This minicomputer is usually in control of the whole Hydra array system.

2 The Hydra Array

This section outlines the mechanical and electrical characteristics of the Hydra array system. There has been a need at DREA for a line array, the length and hydrophone spacing of which could be readily altered to suit water-depth and frequency of interest. It was also required that the array be readily adapted to different deployment configurations such as vertical or horizontal, and be reliable, rugged and easy to deploy. The Hydra array was built to meet this need.

2.1 Mechanical

A typical deployment of the array is shown in Figure 1. Some of the array sensors may be held in the vertical by a float and the rest of the sensors may lie on the ocean bottom. The array is anchored by an acoustic release and weight. The sensors in this array are represented by diamond shapes in Figure 1. These sensors are normally hydrophones. Sensor units are connected by interchangeable cable sections, which allows the array length and sensor interspacing to be easily changed. At one end of the array, there is a microprocessor which controls the sensor electronics. This

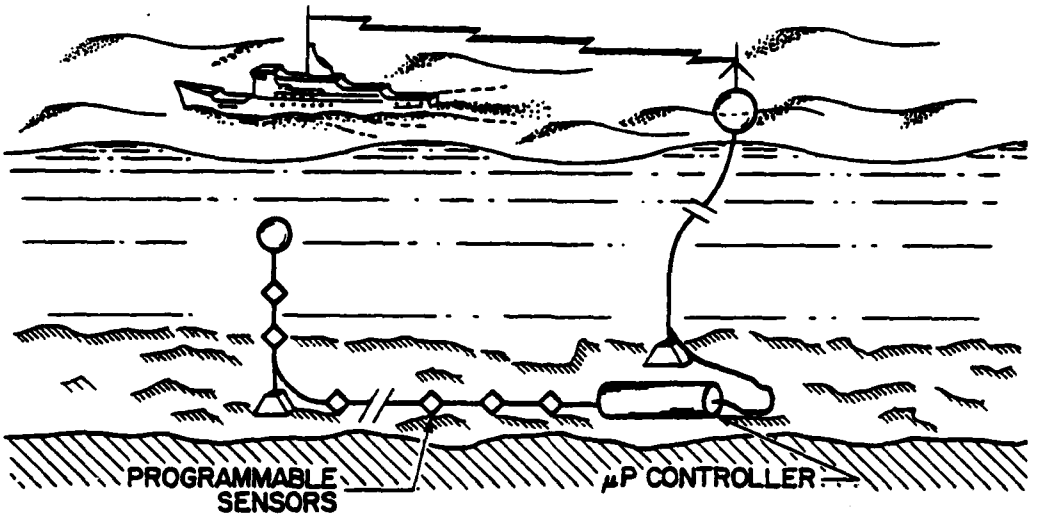


Figure 1. A typical deployment of the Hydra array.

microprocessor unit is linked to a surface buoy by an armoured cable of approximately 700 m length, which carries information between the array and the surface buoy. The surface buoy is tethered to a second weight. Two radio links are used to transmit data to and receive commands from the ship.

2.2 Electrical

The communication and control configuration for the Hydra array is shown in Figure 2. The Hydra array electronics has the form of a digital bus, with hydrophone electronics (or other sensors electronics) connected along it. This array of sensors is controlled at one end by a microprocessor, which in turn is controlled via a radio link by the shipboard minicomputer.

As shown in Figure 2, the entire array system except for the sensor amplifiers and filters is a digital system. The Hydra array system has two modes of operation. The first mode is a control mode, in which array parameters can be changed from the ship. The second mode is a data-acquisition mode, in which data are sent from the sensor electronics to the ship. The mode of operation is normally set by the minicomputer, but the mode can also be set through a simple terminal.

In the control mode, array parameters are loaded by a minicomputer which is on board ship. In this mode, the switches that are shown in Figure 2 are set so that ASCII character data are transmitted from the array to the ship by RS-232 and over the high-speed 168 MHz radio link. At the same time, the minicomputer sends characters over the 27 MHz link from the ship to the wet-end of the array-system. These characters are received in the wet-end of the array-system by the microprocessor and by a simplex

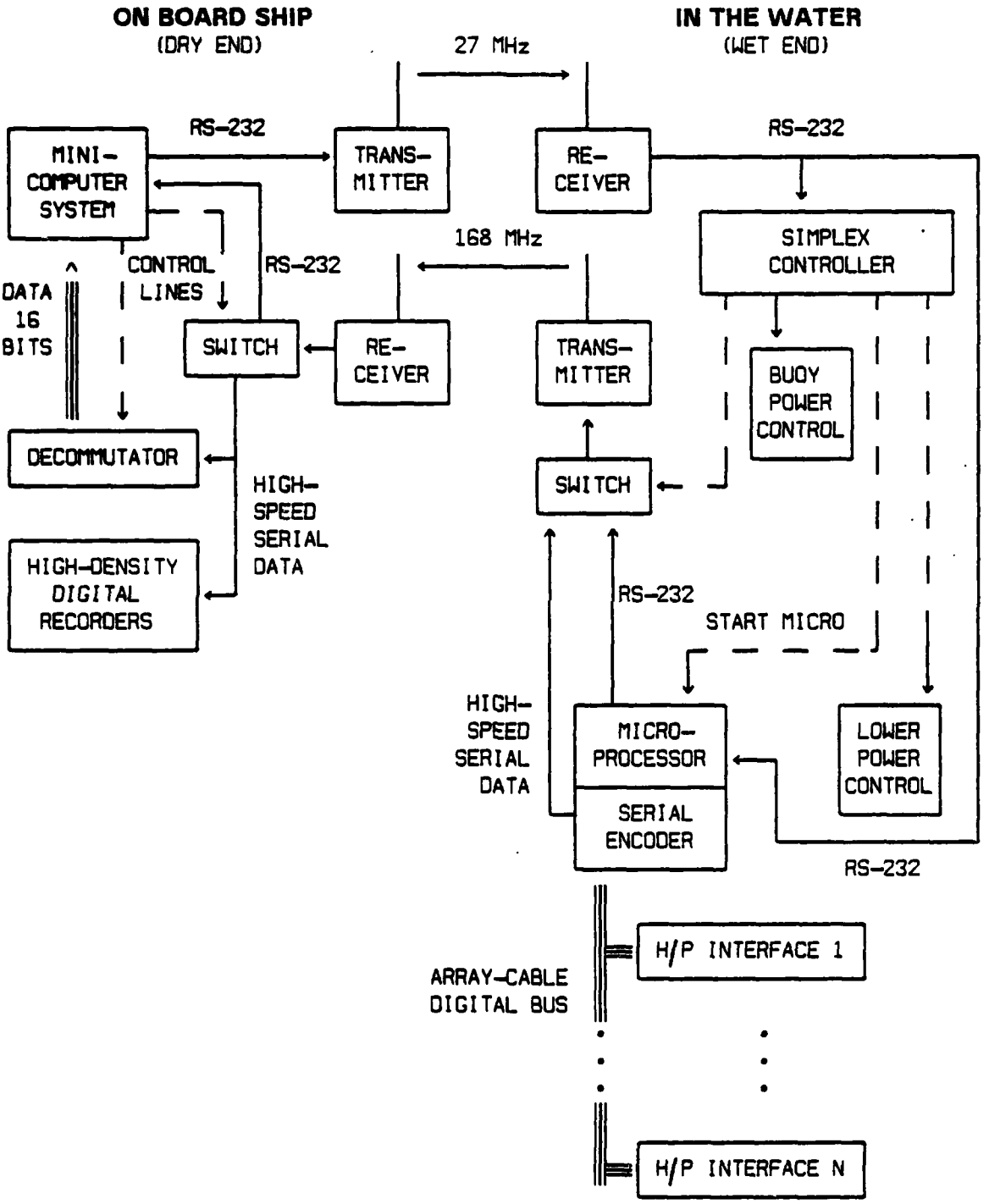


Figure 2. Hydra-array communication and control configuration.

controller. The simplex controller only recognizes a few special control characters. These characters control the power supply for the surface buoy electronics and the power supply for the rest of the array. This simplex controller also controls the mode of operation of the wet-end of the array system and it is used to restart the microprocessor. Characters other than the special control characters are interpreted by the microprocessor. The characters which are sent from the minicomputer to the microprocessor can be used to load a program into the microprocessor from the minicomputer. They can also be used to send information which can be passed on by the microprocessor to the hydrophone interfaces. The microprocessor, as well as receiving characters, can send characters over the 168 MHz radio link back to the minicomputer. The characters received by the minicomputer are used to check that the microprocessor is operating properly and that it is receiving commands correctly.

After turning on the power in the wet-end of the array system, the whole system is left in the control mode, and a program is loaded into the microprocessor. This program is then run, and information is passed from the minicomputer, over the radio link, through the program in the microprocessor, to the appropriately addressed hydrophone interfaces. The designated hydrophones have their associated gains, frequency responses and other characteristics adjusted. When these hydrophone interfaces are properly set, the mode of the Hydra array system is switched to data acquisition. This switching is initiated at the minicomputer which then generates commands to the simplex controller. The simplex controller then calls upon the microprocessor electronics to initiate data acquisition in the hydrophone interfaces.

In the acquisition mode of operation, acoustic data are transmitted at a constant high-speed rate from the array to the ship. The array parameters cannot be changed without interrupting this mode with a command to the simplex controller. Acoustic signals received at the hydrophones are amplified and digitized in the hydrophone interfaces. This design feature avoids crosstalk and phasing problems found in twisted-pair analog systems. When the hydrophone interfaces are switched into data-acquisition mode, those which are not set up for use turn their own power off. The operational interfaces start sending their data up the array-cable bus to the serial encoder. A parallel bit format is used. These data are sent up the bus at times determined by a sequence programmed into the hydrophone interfaces. The serial encoder converts the parallel data words to a high speed serial form. Each hydrophone output is multiplexed into the serial sequence together with injected synchronization words. This serial sequence is then sent up the cable to the surface buoy, and transmitted via the 168 MHz data link to the receiver on board ship. From the ship-board receiver, the data pass through a switch to the high-density digital recorders and also to a decommutator which provides 16-bit parallel data to the minicomputer for on-line analysis.

3 General Software Design

The control software which is described in this document was written to suit the Hydra array hardware outlined in the previous section, and to suit the environment in which this hardware is used. Thus, a brief description of the influence of the experimental environment and of the hardware on the software will help in understanding the software which is described in the rest of this document.

3.1 Experimental Environment

The way that experimental trials are conducted and the way that an acoustic array is deployed in shallow water strongly influenced both the hardware and software design of the Hydra array. The Hydra array is typically deployed with hydrophones on the bottom and in the water column. The hydrophones can be in vastly different acoustic fields. Both the frequency content and the overall signal amplitude can vary strongly from sensor to sensor, making it necessary to have independent control over filters and amplifiers for each hydrophone. Not only can hydrophone signals be vastly different from hydrophone to hydrophone, but the received signals can also change very quickly with time. A typical experiment may consist of dropping explosive charges every few minutes, alternating between shallow and deep charges. The array response characteristics may need to be changed to match each charge. Another consideration is that sensors other than hydrophones may be required, such as tilt/pitch meters to determine the straightness of a vertical array or seismometers to receive shear waves. The software must be designed to make control of such additional sensors easy. Furthermore, the physical deployment of the array is often changed during a trial. Such changes necessitate flexibility in the controlling software. Changes are usually due to different experimental requirements, but occasionally may be due to equipment failure.

The flexibility just described has a cost in the need to keep track of the complex states of the Hydra system. In normal use, a different set of hydrophones with different gains and frequency characteristics may be turned on every few minutes. This reconfiguration is done at the same time that the scientists, programmers and technicians are very busy with other duties. From experience in the early development of the Hydra system, it was found that hand kept logs of the system configuration were often spotty and inaccurate. All the data from sea trials are recorded on high-density digital tape recorders. These recordings contain no system information. Therefore, to keep accurate records of the state of the Hydra system, automatic logs are kept by the controlling minicomputer. Also, the state of the system is automatically recorded along with any acoustic data recorded by the minicomputer. A record of all previous system changes can be printed at anytime.

3.2 Hardware Considerations

The hardware used in the Hydra array sets constraints on the software implementation. Since the wet-end of the array system is battery powered, we chose a microprocessor with low power consumption. At the time of construction, the only microprocessors available with low power consumption had limited speed and capabilities. There was no cross-assembler available for the one we chose until we wrote our own. Thus, the microprocessor's functions are somewhat limited. For efficiency in programming, a high level language (Fortran) is used on the minicomputer to do most of the control, but for reliability, some control is available using software in the microprocessor only. This means that the minicomputer system in Figure 2 can be replaced by a simple terminal for controlling the array. Thus, data collection can continue normally, even if the minicomputer system fails. As well, a technician can control the array for test purposes without tying-up a minicomputer. Because of the hardware design, the software in the microprocessor can be downloaded from the minicomputer. This means that the minicomputer can completely redefine the operation of the wet-end of the array system.

The use of a radio link to pass information between the array and the ship also sets

constraints on the software. For reliability, each character sent to the wet-end of the array system from the minicomputer is interpreted by the microprocessor in the wet-end and then repeated to the minicomputer. The minicomputer compares what it sends with what it receives back, in order to make sure that its messages are received correctly. In the duplex mode which is used for control the data rate is 300 baud, which is quite slow. However, the baud rate of the link is sufficiently fast that when the operator has configured the array operating parameters to his liking and uses the *transmit* command, the entire setup of *every* parameter in the array can be sent from the minicomputer to the microprocessor and implemented in a very reasonable period of time. Approximately 3 seconds, plus 0.3 seconds per hydrophone in use is required. Approximately 95 per cent of this time per hydrophone is for radio data transmission. The complete setup of an array of 16 hydrophones takes approximately 8 seconds, during which time the array is not sending acoustic data to the ship. When a simple terminal (rather than the minicomputer) is used for system configuration, the process takes rather longer - roughly 4 minutes, assuming no errors are made. For a typical experiment, with only a few minutes between gain and filter changes, these changes might not be made fast enough using only the simple terminal. An option that has been used to beat the 300 baud speed limit, is to load a special program into the microprocessor. This program keeps track of the time, and at predetermined times makes changes to hydrophone interface parameters such as gains and filters. This type of program has been used for test purposes: cycling through all states of the array at a high speed. Another limit of the present link is the 655 kbit/second data rate for digitized data being sent from the wet-end of the array system to the shipboard electronics. This limit requires tailoring of the array configuration to match both the experimental requirements and the available data-transmission bandwidth. The Hydra system is flexible enough to allow this tailoring, since one can control the number of sensors turned on, the digitizing rate, and the number of bits per word.

4 Underwater Software

The microprocessor in the wet-end of the Hydra array system requires its own software. A description of the hardware connected to this microprocessor is included in the following section since this hardware strongly influences the software design.

4.1 Hardware Configuration

The hardware in the wet-end of the Hydra array system can be conveniently discussed in three parts. Part one consists of the surface buoy, which communicates with the ship-board electronics over the radio link and communicates down a cable to the lower electronics unit. Part two is the lower electronics unit, which contains the microprocessor and serial encoder. Besides communicating with the surface buoy, the lower electronics unit communicates with the hydrophone interfaces along the array-cable digital bus. Part three consists of the several hydrophone interfaces, which are all essentially identical.

4.1.1 Surface Buoy

The surface buoy contains radio communications equipment, a simplex controller,

and a power supply. The simplex system is used to control a few critical functions of the wet-end of the Hydra system. These functions are listed along with their codes in Table 1. The simplex controller checks for these codes in the normal serial ASCII data stream from the ship. As shown in Table 1, the simplex controller can be used to turn on and off all the power in the wet-end of the Hydra system except for the simplex system's own power. The power can therefore be remotely switched off to save battery power when the array is not being used. The mode of the radio link can also be set. If *transmit ASCII* is selected, then the radio link is switched to enact full-duplex ASCII communication between the ship system and the microprocessor. If *transmit data* is selected, then the radio link is switched to enable high-speed data transmission from the array to the ship. Finally, the simplex system can reset and run the utility program UT4 (described in Section 4.2.1) in order to "boot-strap" the microprocessor. This is done by using the utility program UT4 to bring software into the microprocessor's memory and to start this software.

Table 1

Hydra control codes

<CONTROL> -]	POWER ON SURFACE-BUOY ELECTRONICS
<CONTROL> - X	POWER OFF SURFACE-BUOY ELECTRONICS
<CONTROL> - [	POWER ON SUB-SURFACE ELECTRONICS
<CONTROL> - \	POWER OFF SUB-SURFACE ELECTRONICS
<CONTROL> - T	TRANSMIT DATA FROM ARRAY TO SHIP
<CONTROL> - V	TRANSMIT ASCII FROM ARRAY TO SHIP
<CONTROL> - R	RESET MICROPROCESSOR, RUN UTILITY PROGRAM

4.1.2 Lower Electronics Unit

The lower electronics unit contains the microprocessor and a serial encoder. As shown in Figure 3, the microprocessor is in communication with the ship by an RS-232 serial duplex link, and in communication with the array over a parallel data and command bus. The RS-232 link is used to control the microprocessor; however, this link is in turn controlled by the simplex system.

The microprocessor has control of the hydrophone interfaces over the parallel data bus, and it also has control of the serial encoder. The serial encoder takes parallel data words from the hydrophone interfaces and converts them to a serial stream of data bits including synchronization bits. The serial encoder also produces sampling and calibration signals to be sent to the interfaces. As shown in Figure 3, there are seven control ports which the microprocessor uses to set parameters in the serial encoder. The number of data channels being sent to the ship can be selected by ports 1 and 5. In normal operation, the same number must be output to both ports. A calibration signal can be sent down the bus to the hydrophone interfaces by port 2. The digitization rate to be used at each hydrophone can be selected by port 3. Digitization rates of 8192, 8192/2, 8192/3, 8192/4 etc. (Hz) can be selected. Port 4 is used to directly control the hydrophone interfaces. The number of bits per word can be set in the range from 6 to 12

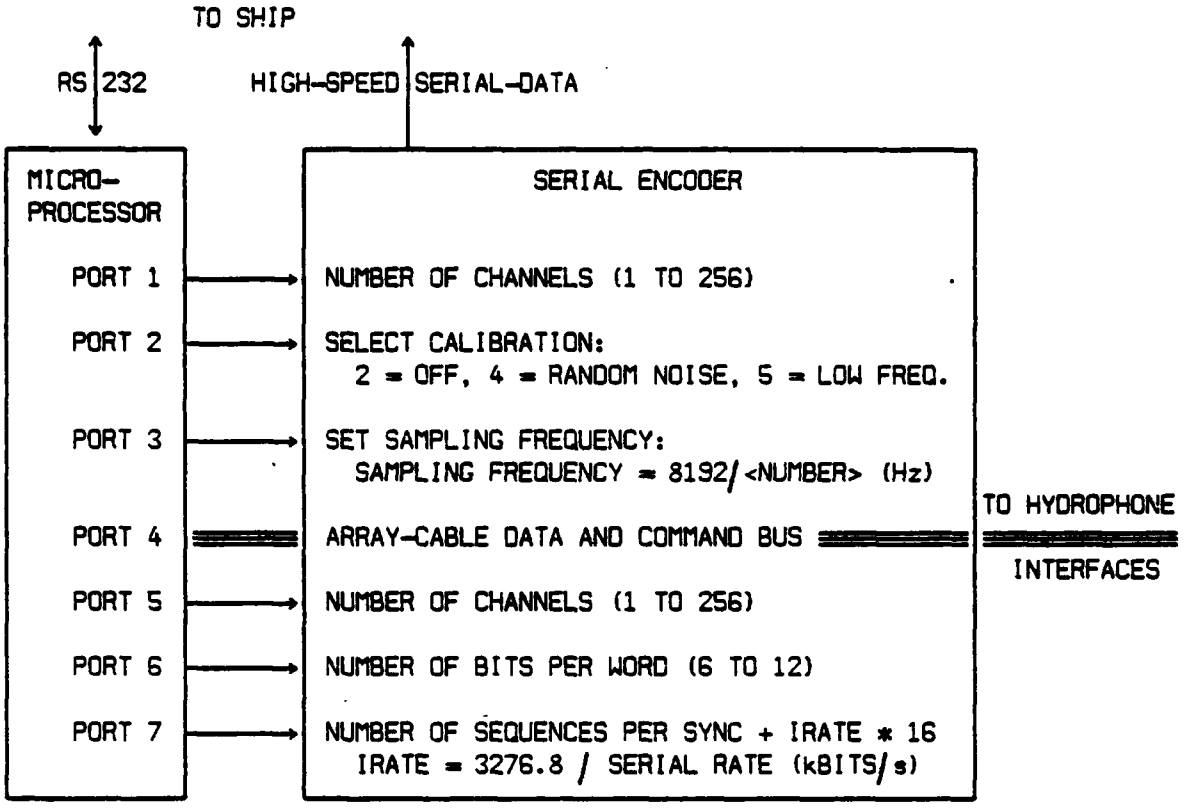


Figure 3. Hydra lower-electronics-unit configuration.

by port 6. Port 7 sets the number of data sequences of all channels before a synchronizing word is sent along the serial data stream.

The memory that the microprocessor can access is shown in Figure 4. There are sixteen 16 bit registers split into bytes. There are 4k bytes of read/write memory (RAM) currently built into the system. The utility read-only memory (ROM) is higher in the address space, with a small amount of read/write memory just above the ROM for use by the utility program.

4.1.3 Hydrophone Interfaces

The microprocessor controls interfaces which are connected to the array-cable data and command bus. These interfaces control many characteristics of the way that the hydrophone signals are conditioned and digitized as shown in Figure 5. The logical number of an interface can be set. This number determines when the interface sends its data back to the ship. In normal use, acoustic signals are received by the hydrophone, passed through a high-pass filter, amplified, passed through a low-pass anti-aliasing filter, digitized, and sent on the array-cable data bus to the serial encoder. The high-pass filter characteristics can be changed to accommodate the low-frequency acoustic

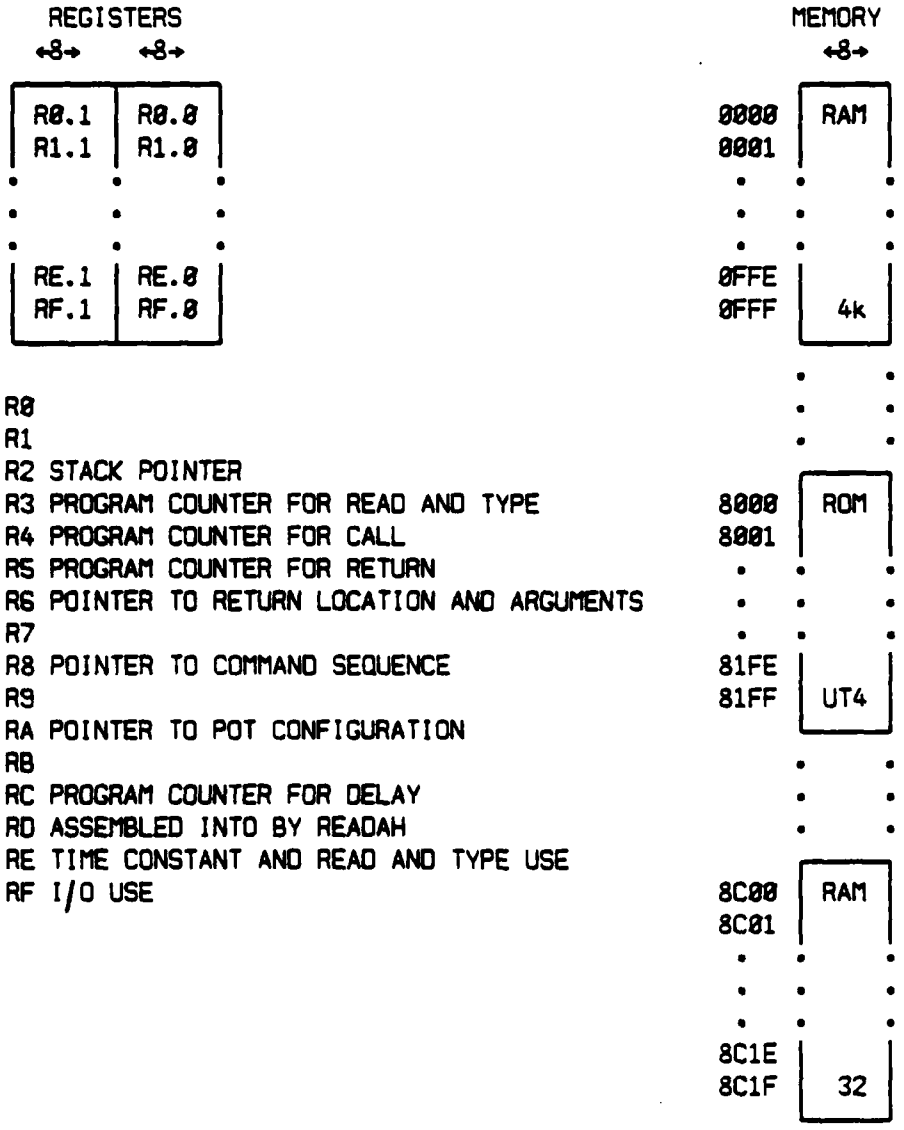


Figure 4. Hydra microprocessor memory and registers.

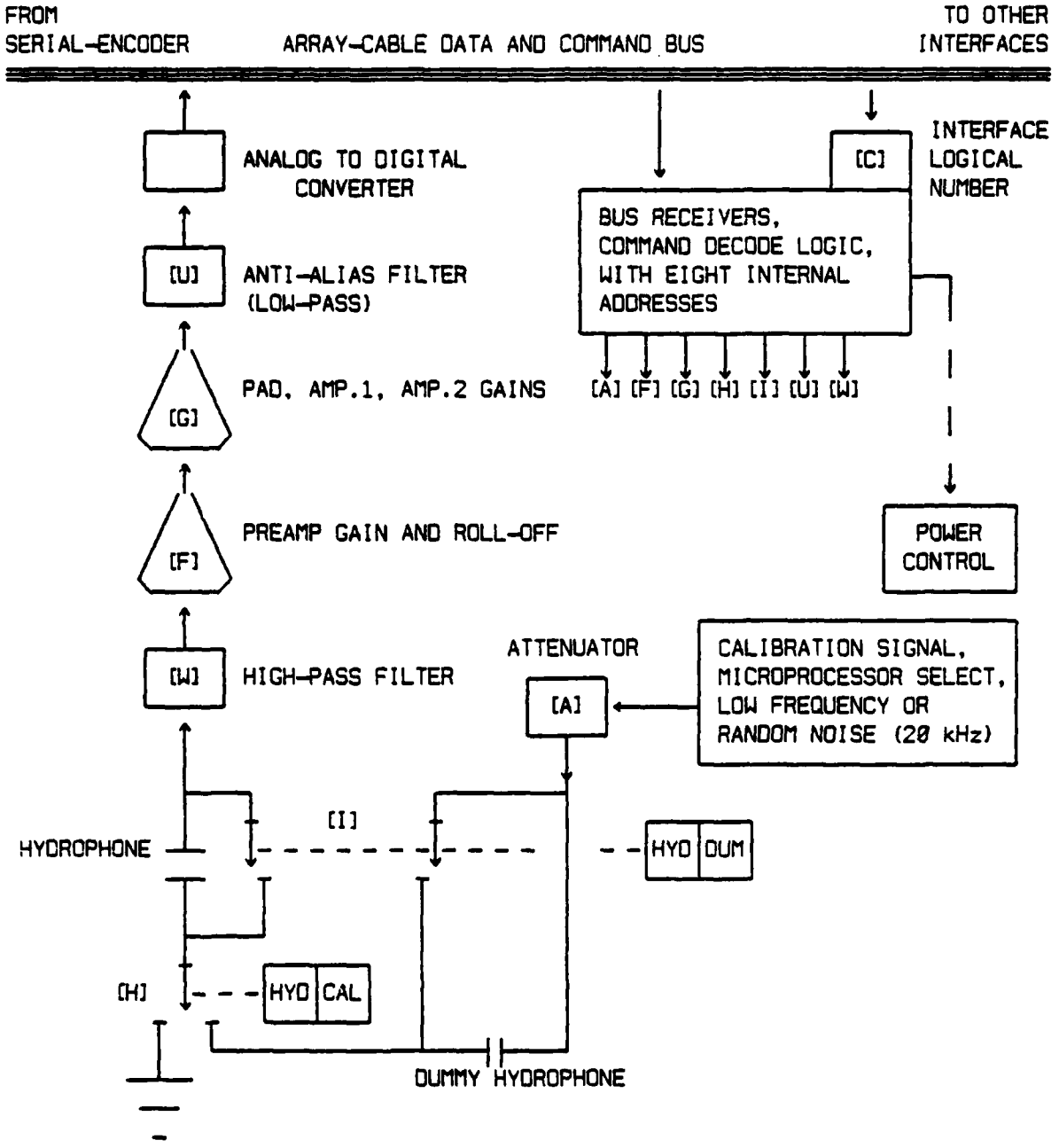


Figure 5. Hydra hydrophone interface configuration. The square-bracketed letters correspond to commands to the minicomputer program CHYDRA which change the associated parameters.

noise characteristics. The low-frequency noise levels vary strongly depending on the sea-state, the hydrophone locations and local shipping. The amplifier gains can be changed to match the overall signal and noise levels. The anti-aliasing filter can be switched out in order to digitize high frequency signals such as acoustic release commands or pings from the ships echo sounder. The acoustic pings from the acoustic release can be used to determine the positions of the hydrophones. In addition to normal data collection from the hydrophone, calibration signals can be internally generated, selected, attenuated and injected past or through the hydrophone to check each individual hydrophone and/or interface.

The format of commands which are sent along the array-cable data and command bus to the interfaces is shown in Table 2. The two high-order bits (7 and 6) define four types of command. The bottom three commands in Table 2 are described first. The address in these commands is the address hard-wired into the individual interface electronics board. The interfaces are also numbered with logical numbers by the *set address* command to determine in what order they will output data back to the ship. The logical number for the interface addressed with this command follows as the next byte on the bus. In order to enter other parameters into an interface, it is opened for writing with the *set Q command*. When all required parameters are entered into the interface, the interface is closed to writing with the *reset Q* command. The last form of command, at the top of Table 2, writes data into a specific location in an interface to control gains, etc.. This command has zeros for the two highest order bits, a three bit internal-interface address, and a three bit data word to be entered into that internal address. The internal addresses are listed in Table 3 and the consequences of entering data into those addresses are listed in Table 4. Typical command sequences used by the microprocessor for controlling the hydrophone interfaces using the command format just described are shown schematically in Figure 6. The two command sequences shown in this figure are used by the manually operated commands of the program UPCP4 (described in Section 4.2.2). There are delays after each command to an interface to allow it to accept the command. The hexadecimal command FF sent to the bus clears it. All the rest of the commands are those listed in Table 2.

Table 2

Hydra data bus command format

```
7 6 5 4 3 2 1 0
0 0|X X X|X X X|  DATA TO BE ENTERED INTO H/P INTERFACE
     DATA ADDRESS

0 1 X X X X X X   SET ADDRESS: NEXT BYTE IS LOGICAL H/P NUMBER
1 0 X X X X X X   SET Q: ADDRESS THIS INTERFACE FOR DATA ENTRY
1 1|X X X X X X|  RESET Q: STOP ACCEPTING DATA INTO THIS INTERFACE
     HARD-WIRED ADDRESS OF INTERFACE
```

Table 3

Hydra hydrophone-interface internal addresses

2 1 0	
0 0 0	AMPLIFIER 1
0 0 1	AMPLIFIER 2
0 1 0	ATTENUATOR
0 1 1	CALIBRATION-SWITCH/PAD WITH R-C FILTER
1 0 0	PREAMPLIFIER
1 0 1	DUMMY-H/P, LOW-PASS-FILTER
1 1 0	CALIBRATION-SWITCH/PAD WITHOUT R-C FILTER
1 1 1	UNUSED

Table 4

Data for Hydra hydrophone-interface internal addresses

DATA 5 4 3	AMP1,2 (dB)	PREAMP (dB)	ATTEN. (dB)	CAL/PAD (dB)	HYD. OR DUMMY, LOW-PASS IN OR OUT
0 0 0	42	42	48	18,HYD	HYD, L.P. IN
0 0 1	36	36	42	36,HYD	DUM, L.P. IN
0 1 0	30	30	36	0,HYD	HYD, L.P. OUT
0 1 1	24	24	30	-	DUM, L.P. OUT
1 0 0	18	18	24	18,CAL	HYD, L.P. IN
1 0 1	12	-	18	36,CAL	DUM, L.P. IN
1 1 0	6	-	12	0,CAL	HYD, L.P. OUT
1 1 1	0	-	6	-	DUM, L.P. OUT

The current versions of hardware and software allow a maximum of 64 sensor interfaces. The array-cable data and command bus is a 12 bit bus, but only 8 bits are presently used for commands, as shown in Table 2. Two of these 8 bits are used for defining the type of command, leaving 6 bits for the hard-wired addresses of the interfaces.

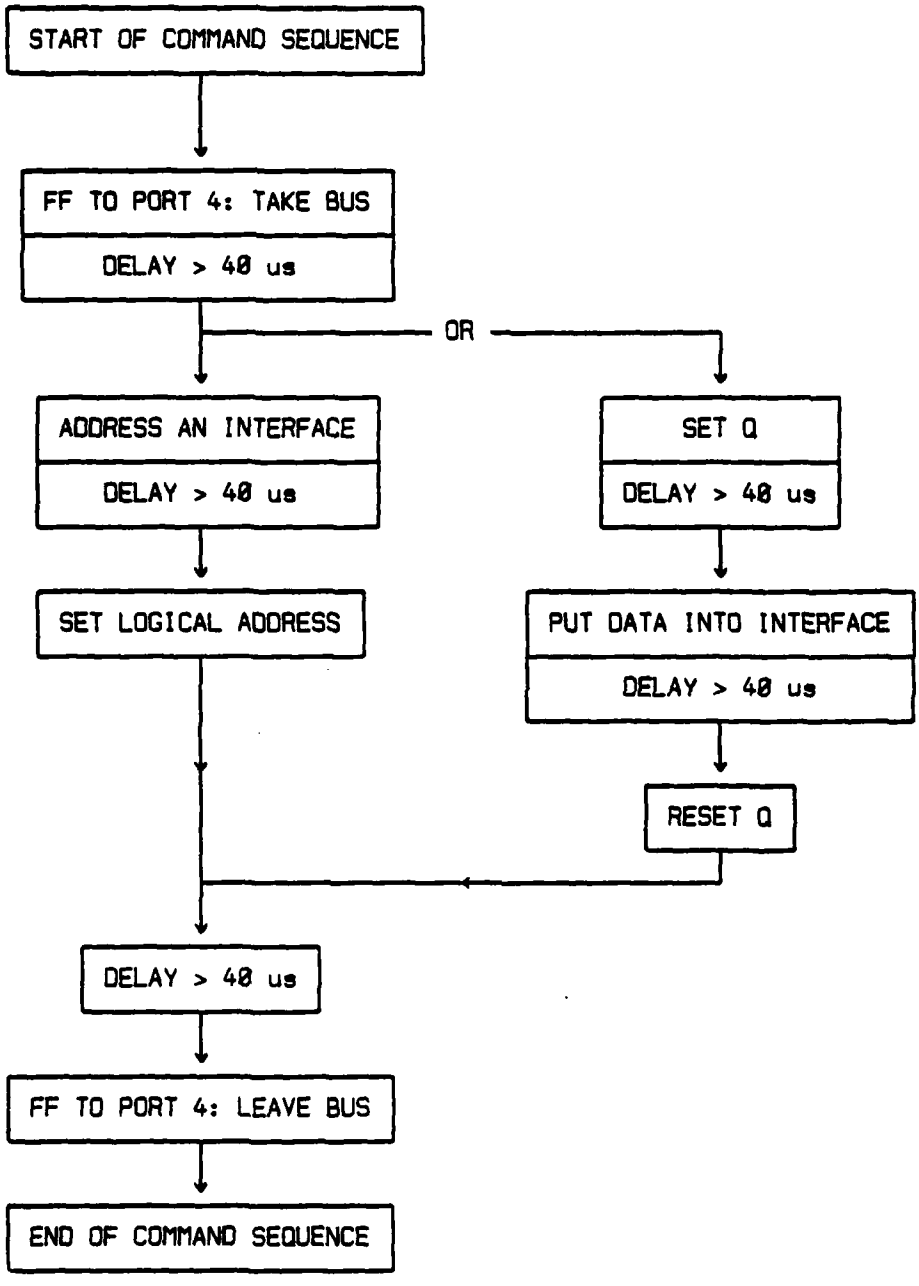


Figure 6. Command sequences for controlling the Hydra hydrophone interfaces.

4.2 Microprocessor Software

The software in the wet-end of the Hydra array system consists of a commercially available general-utility program and a program designed specifically for controlling the Hydra array.

4.2.1 Utility Program UT4

A small package of software called the *utility program* or UT4 is used in most microprocessor operations described here. This utility program is in read-only memory as shown in Figure 4, which makes the program available as a boot-strap to the microprocessor, and also makes it invulnerable to data-link problems. The utility program is used for all serial input/output operations of the microprocessor, for downloading software into microprocessor read/write memory, and for some microprocessor program timing. The commands available with UT4 through the microprocessor's RS-232 input are listed below:

?M<address> <count><CR>	Lists the contents of <count> bytes of memory starting at <address>.
!M <address> <data><CR>	Puts <data> into memory starting at <address>, where <data> consists of a hex pair for each byte.
$P<address><CR>	Starts program execution at memory location <address>.

As well as running UT4 directly, some of its subroutines are called from the control program UPCP4. The subroutines in UT4 that are of use when programming the microprocessor are listed below:

CALLING SEQUENCE		NAME	FUNCTION PERFORMED
SEP	$C	DELAY	Delay for a time given by <delay number>.
.BYTE	<delay number>		
SEP	4	READAH	Read an ASCII character into register RF.1.
.WORD	$813B		If a hex digit, then hex value put in register D and DF = 1. If not a hex digit, then DF = 0.
SEP	4	TYPE	Type the ASCII character from register RF.1.
.WORD	$81A4		
SEP	4	TYPE6	Type the ASCII character <character>.
.WORD	$81A2		
.BYTE	<character>		

Note that all reading and typing in the above subroutines is done through the microprocessor's RS-232 input/output connection.

4.2.2 Control Program UPCP4

The microprocessor program which is currently used for control of the Hydra array is called UPCP4. It has code which allows the array to be controlled with a simple terminal.

The program also has code which allows a minicomputer on the ship to do the controlling. This program is downloaded from the ship, usually from the minicomputer, but sometimes from a terminal with a tape cassette reader. Tape cassettes have been prepared with pre-recorded programs.

The commands for the control program UPCP4 are listed in Appendix B. The minicomputer uses the utility program UT4 to load an array configuration table from the minicomputer into the microprocessor's memory, and to start the program UPCP4. The minicomputer then uses command Z in UPCP4 to set up the entire array from that table. The minicomputer also uses the command UT4<CR> to return to the utility program. The remaining commands in this control program are for use from a terminal on the ship.

The subroutine calls which are used in the control program UPCP4 are listed separately in Appendix D. These calls handle terminal input/output, menu-branching and output to the array-cable data and command bus. They are also listed along with the main body of the program in Appendix F.

5 Shipborne Software

The main control software for the Hydra array resides in a minicomputer on board the ship. Since the control software is influenced by the hardware and operating system environment, this environment is described first. The control software obtains information about the array configuration from the operator while being used to control the array. This information is then passed on to other programs in the minicomputer. The information transfer is described at the end of this section.

5.1 Hardware Configuration

The shipboard control hardware, shown in Figure 7, consists of a minicomputer which is in communication with the wet-end of the array system using a radio transmitter and receiver, a terminal which displays the current set-up of the array, and a console terminal to control the minicomputer. The minicomputer has peripherals including a time code reader/generator, a removable 5 Mbyte disk, an 80 Mbyte fixed disk, and two 125 inch/s 9-track tape-drives. The time code reader/generator is used as the master time reference for all data gathering. The data recording hardware is also shown in Figure 7. The decommutator-box converts the high-speed serial data from the array into parallel 16-bit words which are sent to the minicomputer for analysis. The decommutator-box also provides analog reconstruction of the digital data from the array. The decommutator-box is internally controlled by a microprocessor running a BASIC interpreter. This microprocessor is controlled by the minicomputer, but its operation will not be described in this document. There are also high-density-digital-tape recorders which are capable of continuous recording at 655 kbits/s for fourteen hours without attention.

5.2 Operating System

The minicomputer software runs under the Digital Equipment Corporation's RT-11 real-time operating system. This operating system is used for almost all input/output from the program CHYDRA (described in Section 5.3). One of the disks connected to the

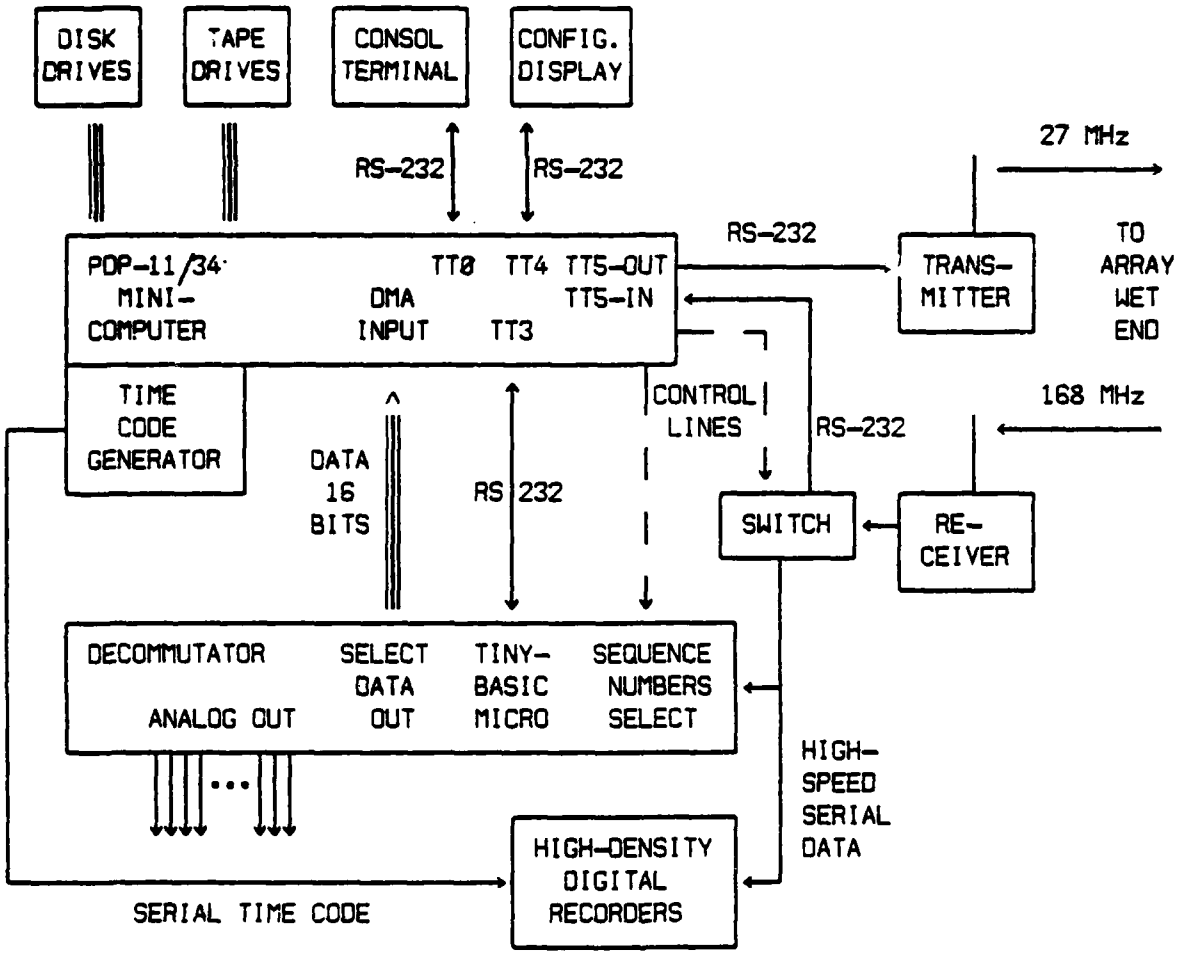


Figure 7. Hydra shipboard hardware configuration.

minicomputer is designated as the "operating-system disk". The files used by program CHYDRA are kept on the minicomputer's operating-system disk, and software to be transferred to the microprocessor by CHYDRA may be kept on any of the minicomputer's storage devices.

There are a few operating system commands that may be required while operating the Hydra array. In the following description, what is typed by the user is bold, and *what is typed by the computer is in italics.* <CR> means carriage-return. When the minicomputer is first turned on or restarted by pressing the front-panel "boot" button, a diagnostic code and a $ prompt appear on the console. Respond to the prompt as shown below to get RT-11 started:

$DB<CR>

The system will start, give some initial messages, then wait for commands while displaying a . prompt. Some of the possible commands are:

.R CHYDRA<CR>	Runs the control program CHYDRA.
.PRINT SY:CHYDRA.LOG<CR>	Prints past system configurations.
.RENAME SY:CHYDRA.LOG <new filename>	To save an old log file.

See the PDP-11/34 and RT-11 user manuals for further information.

5.3 Control Program CHYDRA

The program which is normally used for overall control of the Hydra array is called CHYDRA, and is listed in Appendix G. This program controls the Hydra array, displays its configuration on a video terminal, passes the array configuration to succeeding programs, records a log of configurations used during a trial, and allows the user to print the current configuration on a line printer.

The CHYDRA program consists of a mainline routine which provides a menu of functions for the operator, and 22 subroutines to carry out those functions. The subroutines can be divided into several classes: input/output subroutines, configuration-editing subroutines, and numerical-conversion subroutines. These subroutines are described in Appendix E.

5.3.1 Use of the Control Program CHYDRA

The control program CHYDRA is used regularly during a typical trial. CHYDRA is used to load the software into the wet-end of the array system before deployment, and to set up the array for monitoring during deployment of the array. For monitoring ambient noise, CHYDRA is used to tailor the response of the array to the ambient noise received at each sensor. The relatively-large acoustic dynamic range of the array and the slow temporal change in ambient noise usually only necessitate changes in array response on a scale of hours. For monitoring sound arrivals from explosive sound sources, gain changes may be required as frequently as every few minutes.

At some time in a trial, the array may be set up for calibration. Precision levels of pseudo-random electrical noise are injected in series with each hydrophone, controlled through the CHYDRA program. The gain settings to be calibrated are selected and the resulting calibration signals are recorded like normal acoustic data. These calibration signals may be used as diagnostic tools to reveal faulty components of the array.

The hydrophone positions may also be localized with the help of the CHYDRA program. The anti-aliasing filters may be bypassed using CHYDRA commands so that pings from the acoustic releases can be recorded. These pings can give ranges from the acoustic releases to the hydrophones by several paths. Knowing these ranges along with ranges from another source (usually long-range explosive sounds) allows triangulation to determine the hydrophone positions.

After completion of a trial, the log file or files that were created by CHYDRA are printed for subsequent reference.

The actual command sequences used to do the typical operations described in the four previous paragraphs are described in Appendix C.

5.3.2 Display Format of Array Configuration

One display format of the array configuration is used for the console-terminal, the configuration display, printer output and for the log-file. This format is shown in Figure 8. The date and time at which the array is set-up are recorded from the master time-code generator, along with the version date of the CHYDRA program. The command codes necessary to change the listed values are given in the display [enclosed in square brackets], for quick reference. All the CHYDRA commands ask for a beginning pot number and an ending pot number so that large numbers of hydrophone interfaces can be changed at the same time in order to speed up editing of the configuration table.

```
DATE: 83- 6-29,     TIME: 12:34:31.463,     CHYDRA version 83-5-16

POT WIRED PRE-AMP  PAD,G1,G2 HIPASS AALIAS HYD HYD ATTEN  TOTAL   POT
 #    #   GAIN(dB) GAIN(dB)  FILTER FILTER CAL DUM  (dB) GAIN(dB)  #
     [C]    [F]       [G]      [W]    [U]  [H] [I]  [A]

 1 -  1 --- 42 -----  12 -----  IN -- OUT  HYD HYD  42 ---  54 --  1
 2 -  2 --- 42 -----  18 -----  IN -- OUT  HYD HYD  42 ---  60 --  2
 3 -  4 --- 42 -----  24 -----  IN -- OUT  HYD HYD  42 ---  66 --  3
 4 -  3 --- 42 -----  30 -----  IN -- OUT  HYD HYD  42 ---  72 --  4
 5 - 13 --- 42 -----  30 -----  IN -- OUT  HYD HYD  42 ---  72 --  5
 6 - 19 --- 42 -----  30 -----  IN -- OUT  HYD HYD  42 ---  72 --  6
 7 - 11 --- 42 -----  30 -----  IN -- OUT  HYD HYD  42 ---  72 --  7
 8 - 12 --- 42 -----  30 -----  IN -- OUT  HYD HYD  42 ---  72 --  8
 9 - 15 --- 42 -----  30 -----  IN -- OUT  HYD HYD  42 ---  72 --  9

>>> END OF LOG FILE ==========================
```

Figure 8. CHYDRA log-file and display format. Note that the letters in square brackets refer to commands in CHYDRA used to change values in the corresponding columns.

There are two labels shown in Figure 8 which can be quite confusing. The *POT #* label refers to the number in the sequence in which data is sent from the array to the ship. *POT #* is also referred to as *sequence number* and *logical number*. The *WIRED #* label refers to a particular set of electronics in one hydrophone pot. This wired number is the one that is always kept with the data, since the wired number refers to one specific hydrophone and related electronics.

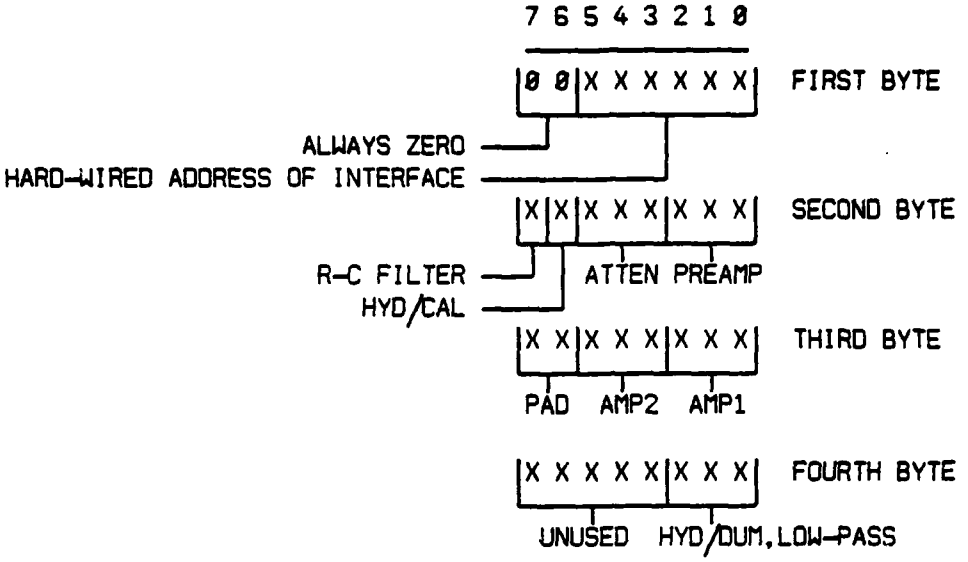
5.3.3 Internal Format of Array Configuration

There is a much more compact internal format for the information contained in the display format of Figure 8. This internal format is stored on the minicomputer's operating-system disk to provide the previous array configuration upon starting CHYDRA. The configuration is stored in this format while being edited inside the CHYDRA program, and is transferred to the microprocessor and stored in the same format. Since the transfer takes a significant time over the 300 baud radio link to the array, a compact format is

Table 5

Internal format for the set-up

of one Hydra hydrophone interface



needed. The format shown in Table 5 is as compact as possible. Each interface currently has a maximum of 8 internal addresses containing 3 bits each (see Table 3 and Table 4), although only 19 of these 24 bits are presently used. Thus, the minimum number of bytes to fill these locations is 4, including the hard-wired address of the interface.

5.3.4 Interface Gain Control

The gains of the hydrophone amplifiers must be controlled in an optimum way, since there are 960 possible gain settings! Most of these gain settings are redundant, so a judicious choice of optimum gain configurations is made to obtain the lowest noise and to keep the number of gain combinations to a minimum. These optimum gain configurations are listed in Figure 9, which is the actual file CHYDRA.GAN that is read from by the program CHYDRA to determine the way in which it sets up the amplifier gain stages. You will note in Figure 8 that the preamp gain is specified separately from the rest of the gains. This is because the high-pass characteristics of the preamp depend on its gain. Therefore, both the preamp gain and another high-pass filter can be independently controlled to set the high-pass characteristics for each individual sensor.

The hexadecimal format of the gain codes in Figure 9 is chosen so that the third byte shown in Table 5 can be filled directly. Only the left column of hexadecimal numbers in Figure 9 are read by CHYDRA. The rest of the file is just a description of how the hexadecimal numbers are produced. The binary equivalents of the hexadecimal numbers are shown broken up into the bits used for the pad, gain 2 and gain 1. To the right of

HEX	PAD G2 G1 BINARY	PAD (dB)	G1 (dB)	G2 (dB)	TOTAL (dB)	#
7F	01 111 111	-36	0	0	-36	1
7E	01 111 110	-36	6	0	-30	2
7D	01 111 101	-36	12	0	-24	3
3F	00 111 111	-18	0	0	-18	4
3E	00 111 110	-18	6	0	-12	5
3D	00 111 101	-18	12	0	-6	6
BF	10 111 111	0	0	0	0	7
BE	10 111 110	0	6	0	6	8
BD	10 111 101	0	12	0	12	9
BC	10 111 100	0	18	0	18	10
B4	10 110 100	0	18	6	24	11
AC	10 101 100	0	18	12	30	12
A4	10 100 100	0	18	18	36	13
A3	10 100 011	0	24	18	42	14
9B	10 011 011	0	24	24	48	15
9A	10 011 010	0	30	24	54	16
92	10 010 010	0	30	30	60	17
91	10 010 001	0	36	30	66	18
89	10 001 001	0	36	36	72	19
88	10 001 000	0	42	36	78	20
80	10 000 000	0	42	42	84	21

THIS FILE IS AN OPTIMUM GAIN TABLE

PHILIP STAAL, 15:55pm Saturday, 15 November 1980

Figure 9. File of optimum gain configurations used for Hydra: CHYDRA.GAN

these, the individual gains corresponding to the binary numbers are shown. Finally, the totals of these gains are shown beside their row numbers.

5.4 Data Transfer to Related Software

The CHYDRA program is normally run before a data acquisition program. Since data acquisition programs store data from the Hydra array, they need information on the array configuration. This information is passed to them in the file CHYDRA.2DA which is on the operating-system disk.

The file CHYDRA.2DA is a one-block file which can be read into an integer array of 512 bytes such as LABEL(1 to 512). The format of this file is given in Figure 10. The number of hydrophone interfaces that are used is stored in LABEL(1). Each one of the interfaces in use is described with four bytes (such as LABEL(2) to LABEL(5) for interface 1). The first of these four bytes is a binary number representing the wired number of the interface to which the remaining three bytes apply. The second byte is a binary number representing the total gain (in decibels) of the interface. The third byte is

```
LABEL(1) = <number of hydrophone interfaces>

LABEL(2) = <wired number of interface>
LABEL(3) = <total gain of interface (dB)>      ─ Interface 1
LABEL(4) = <ASCII preamp gain (6dB)>
LABEL(5) = <ASCII interface-code character>

LABEL(6) = <wired number of interface>
LABEL(7) = <total gain of interface (dB)>      ─ Interface 2
LABEL(8) = <ASCII preamp gain (6dB)>
LABEL(9) = <ASCII interface-code character>
   .                    .
   .                    .
   .                    .
LABEL(254) = <wired number of interface>
LABEL(255) = <total gain of interface (dB)>    ─ Interface 64
LABEL(256) = <ASCII preamp gain (6dB)>
LABEL(257) = <ASCII interface-code character>
```

Figure 10. File format for data transfer to *Hydra* data acquisition software: CHYDRA.2DA

an ASCII character in the range from "3" to "7" which represents the preamp gain. The preamp gain (in decibels) is determined by multiplying this character by 6. For example, if the <ASCII preamp gain (6dB)> is "7", then the preamp gain is 7x6 = 42 dB. The fourth byte is an ASCII character in the range from "A" to "H" or "Q" to "X". The conversion from this ASCII interface-code character to filter and hydrophone status is given in Table 6. For example, if the <ASCII interface-code character> is "A", then there is no calibration signal, the high-pass filter is out, the low-pass filter is in, and the input is from the hydrophone. The reason for this ASCII coding is that the current DREA-standard time-series file header has no locations defined for frequency response or calibration specifications.

Table 6

Conversion from ASCII character codes

to filter and hydrophone status in the Hydra array

ASCII INTERFACE-CODE CHARACTER	HYDROPHONE OR CAL	HIGH-PASS FILTER	LOW-PASS FILTER	HYDROPHONE OR DUMMY
A	HYD	OUT	IN	HYD
B	HYD	OUT	IN	DUM
C	HYD	OUT	OUT	HYD
D	HYD	OUT	OUT	DUM
E	HYD	IN	IN	HYD
F	HYD	IN	IN	DUM
G	HYD	IN	OUT	HYD
H	HYD	IN	OUT	DUM
Q	CAL	OUT	IN	HYD
R	CAL	OUT	IN	DUM
S	CAL	OUT	OUT	HYD
T	CAL	OUT	OUT	DUM
U	CAL	IN	IN	HYD
V	CAL	IN	IN	DUM
W	CAL	IN	OUT	HYD
X	CAL	IN	OUT	DUM

6 Concluding Remarks

The Hydra array system is very versatile and, as a result, very complex. Therefore, a relatively sophisticated software package is required to control the system, to display its configuration, and to log automatically the highly variable states of the system. Such a software package, described in this document, has been used to great advantage during the development of the Hydra array and during a multitude of different deployments over the past four years.

The Hydra array, controlled with the software described in this document, has been used to collect data reported in a number of papers, two of which are listed here: [Chapman and Ellis, 1982], and [Staal, 1983].

Having control software in the wet end of the array system as well as on the ship has proven to be advantageous. A simple terminal can be used to control all functions of the array without the rest of the shipborne computers. This enhances the reliability of the system, and enables technicians to work on the array without tying up a minicomputer. Also, the microprocessor in the wet end of the array system can do real-time changes to the array without intervention over the radio link by the shipborne minicomputer. Despite this split in the software package between the two processors, the minicomputer can have complete control, since it down-line-loads the software for the microprocessor.

Appendix A

Glossary

ASCII	American Standard Code for Information Interchange: Coded character set to be used for the general interchange of information among information-processing systems, communications systems, and associated equipment.
BAUD	A unit of telegraph signaling speed equal to the number of code elements (pulses and spaces) per second or twice the number of pulses per second.
BUS	One or more electrical conductors along which information and/or power is transmitted from any of several sources to any of several destinations.
COMMUTATOR	A device which combines several parallel data streams into a serial one.
CROSS-ASSEMBLER	A program which runs on one computer and converts symbolic computer code into machine language for a different type of computer.
DECOMMUTATOR	A device which separates a serial data stream into several parallel ones.
DMA	Direct Memory Access: The use of special hardware for direct transfer of data to or from memory to minimize the interruptions caused by program-controlled data transfers.
DOWNLOAD	To load a program stored in one computer into the memory of a second computer.
DUPLEX	The operation of associated transmitting and receiving apparatus concurrently, as in ordinary telephones, without manual switching between talking and listening periods.
FIFO	First-In, First-Out memory: Typically used for buffering data between asynchronous devices, or as a delay device.
FSK	Frequency Shift Keying: A method used for transferring digital information, in which different frequencies correspond to different discrete characters or symbols. Normally, one frequency corresponds to 1 and another frequency corresponds to 0.
H/P	HydroPhone: A device which receives underwater sound waves and converts them to electric waves.
POT	Hydrophone units including hydrophones, amplifiers, filters, interfaces etc. are loosely termed *pots*.

RAM	Random Access Memory: A data storage device having the property that the time required to access a randomly selected datum does not depend on the time of the last access or the location of the most recently accessed datum.
RF	Radio Frequency: A frequency at which coherent electromagnetic radiation of energy is useful for communication purposes; roughly the range from 10 kHz to 100 GHz.
ROM	Read Only Memory: A device for storing data in permanent, or non-erasable, form; usually a static electronic or magnetic device allowing extremely rapid access to data.
RS-232	An electrical and mechanical standard for connecting devices which send and receive information. Used to connect computers to computers, and computers to terminals, etc.
SHOT	An explosive underwater sound source.
SIMPLEX	A mode of radio transmission in which communication takes place between two stations in only one direction at a time.
SYNC WORD	Synchronization word: A digital word, chosen so that it is reliably detected, and used to mark the beginning of, or other known position in, a data sequence.
WET-END	The *wet-end* of the array system includes the array itself and directly connected electronics.

Appendix B

Instructions for Microprocessor Program UPCP4

In the following description, **what is typed by the user is bold**, and *what is typed by the computer is in italics.*

The UT4 utility program types a * when waiting for a command. Typing **$P0<CR>**, where <CR> means Carriage-return, will start UPCP4.

The main routine types @ when waiting for one of the following commands:

UT4<CR>	Return to the UT4 utility program
LOW FREQ<CR>	Turn on the low-frequency calibration signal
RANDOM NOISE<CR>	Turn on the random-noise calibration signal
HALT CAL<CR>	Stop the calibration signal
BITS/WORD: <number><CR>	Set number of bits/word (6 to 12)
SEQ/SYNC: <number><CR>	Set number of sequences/sync (1 to 16)
# OF CHANNELS: <number><CR>	Set number of channels (1 to 63)
DIGITIZATION RATE: <number><CR>	Set digitization rate = 8192/<number> (Hz)
Z<CR>	Set up all H/P's from configuration table
POT #: <number><CR>	Set the logical interface number for one H/P. The program then types > and waits for one of the following commands:
WIRED #: <number><CR>	Set the interface address (base 16)
G0, DB: <number><CR>	Set preamp gain (18 to 42 dB)
G1, DB: <number><CR>	Set amplifier 1 gain (0 to 42 dB)
G2, DB: <number><CR>	Set amplifier 2 gain (0 to 42 dB)
ATTEN DB: <number><CR>	Set attenuator (0 to 42 dB)
	The pad may be 0, 18 or 36 dB:
HYD, H.P. FILTER (Y OR N)? <Y or N>, **PAD DB:** <number><CR>	
C, H.P. FILTER (Y OR N)? <Y or N>, **PAD DB:** <number><CR>	
DUMMY (Y OR N)? <Y or N>, **L.P. FILTER (Y OR N)?** <Y or N>	
	Anything else will cause a return to the @ prompt

Appendix C

Instructions for Minicomputer Program CHYDRA

The following set of instructions explain what is required of the operator to set up the Hydra array, assuming that the hardware and software are in place. In the following description, what is typed by the user is bold, and *what is typed by the computer is in italics*. <CR> means carriage-return.

First, start the CHYDRA program following the RT11 prompt:

.R CHYDRA<CR>

? = List of available commands
Q = Quit back to monitor
A = Attenuator change
C = Configuration of array change
D = Direct connection of terminal to microprocessor
F = Frequency response (preamp gain) change
G = Gain of post amps change
H = Hydrophone or Cal change
I = Input hydrophone or capacitor change
L = Load microprocessor from PDP11 disk file
P = Print array configuration table
T = Type array configuration table
U = Upper frequencies (anti-alias filter) change
W = High-pass filter change
X = Transmit and setup array configuration

COMMAND ?

You can now do any of the functions listed in this menu by typing the appropriate character followed by <CR>. To start the array from power-up, type D<CR>. The terminal will then appear to be directly connected to the microprocessor. The utility program should be started, using the commands listed in Table 1. The prompt * will be displayed when the utility program has started. Then, to get out of direct mode, type <CTRL-C><CTRL-C>. To load the program into the microprocessor, type L<CR> after the *COMMAND ?* prompt. The computer will then display *INPUT FILE NAME ? **. Type the file name UPCP4<CR> and the microprocessor will be loaded. The computer will then prompt you for another command. The number of bits per word, number of channels, number of sequences per sync and the digitization rate should be set by using command D and the instructions for the microprocessor program UPCP4 in Appendix B. Then the microprocessor should be left with the utility program running. To get out of direct mode, type <CTRL-C><CTRL-C>.

At this point, type T<CR> in response to the *COMMAND ?* prompt. You will see a display of the present array configuration similar to that in Figure 8. If you wish any changes to the configuration of the table, use the editing commands A, C, F, G, H, I, U or W to do the changes. When you are satisfied with the array configuration displayed, use

the command X to transmit the configuration and set up the array. Note that any hydrophone pots that have not been addressed in the displayed configuration will be turned off to save power. To turn all the hydrophone pots back on, you must power down the sub-surface electronics and re-power it using the D command and the commands in Table 1.

At any point, you may print the current array configuration table on the line printer with command P or type the table on your terminal with command T.

When you are through changing the array, ***always stop the CHYDRA program by using command*** Q. This is because the program must store the current configuration in CHYDRA.CFG for the next time CHYDRA is run. It must also store the configuration in CHYDRA.2DA for data acquisition programs and in CHYDRA.LOG for the continuing history of the array. If you stop the program with a <CTRL-C>, none of these things will be stored.

The CHYDRA.LOG file is defined to be 150 blocks, which is large enough to store roughly 50 array configurations. If the file becomes full while the program CHYDRA is storing an array configuration in it, the program tells you to rename the current CHYDRA.LOG file, to run CHYDRA again, and to quit CHYDRA in the normal fashion. The program will then create a new CHYDRA.LOG file, and store the last configuration in it.

Appendix D

Subroutines Used in Microprocessor Program UPCP4

CALLING SEQUENCE	NAME	FUNCTION PERFORMED
SEP 4 .WORD ‹subroutine address›	CALL	Calls a subroutine. This is used to implement all the other subroutine calls below.
SEP 5	RETURN	Returns from a subroutine.
SEP 4 .WORD BRNG .BYTE 'A' A 'B' B 0	BRNG	Gets one character from the console and branches to the address corresponding to the character. In this example, if *A* is typed the program branches to label A, if *B* is typed the program branches to label B, and if anything else is typed the program just continues.
SEP 4 .WORD CHKCR BR ‹address to go to if NOT carriage-return› ‹continues here if a carriage-return was received›	CHKCR	Gets one character from the console and branches accordingly.
SEP 4 .WORD CHK2 BR ‹address to go to if NOT carriage-return› ‹continues here if a carriage-return was received›	CHK2	Does the same as CHKCR except that the character to be checked is already in register RF.1
SEP 4 .WORD BEL	BEL	Types ?<*BELL*> to the console terminal.
SEP 4 .WORD NTRNO BR ‹error address› ‹continues here if a carriage-return was received›	NTRNO	Types : and accepts a two-digit decimal number from the console terminal. The hex equivalent is stored in register RD.1.
SEP 4 .WORD BLKTYP .WORD ‹address to start› .BYTE ‹number of characters›	BLKTYP	Types ‹number of characters› characters starting at ‹address to start› to the console terminal.
SEP 4 .WORD BUSOUT	BUSOUT	Outputs a number of commands down the bus to the hydrophone interfaces.

Appendix E

Subroutines Used In Minicomputer Program CHYDRA

E.1 Input/Output Subroutines

QSTN	This subroutine types the list of available commands on the console terminal.
QUIT(IM)	This subroutine returns to the monitor in a graceful fashion. QUIT stores the current configuration in CHYDRA.CFG, appends the configuration to CHYDRA.LOG, and outputs the configuration to CHYDRA.2DA for the data acquisition programs.
DIRECT(ITER)	This subroutine connects the console terminal directly to terminal number ITER. To pass out of direct mode, type two control-C's in a row.
SETTER(UNIT,OPEN)	This subroutine attaches the terminal UNIT and normally sets it for no echo, no wait, tab, form, no CR LF on carriage limit, handle XON/XOFF, no handle <control>-F,<control>-B,<control>-X, and pass all out if OPEN = 1. Pass all in is set if OPEN = 2. If OPEN = 0, then the terminal UNIT is reset to the initial characteristics and detached. If UNIT = 5, the FSK xmit is turned on and ASCII xmit is enabled for OPEN.NE.0, and the FSK xmit is turned off and data xmit is enabled for OPEN = 0. The baud rate is normally set to 300 baud. However, if UNIT = 4, then the baud rate is set to 9600 baud.
DOWNLD(IM)	This subroutine asks for a single dump disk file, which is then downline loaded to the micro-processor. The program UPCP4 is the most commonly used dump file.
FILEIN(IFNAME,ISTART,IM,NCHAR)	This subroutine inputs and converts to LOAD format, the disk dump file specified by IFNAME, into the virtual array IM, starting at IM(ISTART). The number of elements read into IM is NCHAR. This subroutine is used by DOWNLD to get the dump file off disk.
LOAD(ISTART,ISTOP,MSTART,IM)	This subroutine takes the memory image for the microprocessor stored from IM(ISTART) to IM(ISTOP), and downline loads it starting at the micro address specified by MSTART. This is used for loading programs and for sending array configuration information to the microprocessor.

ICLEAR — This function outputs anything remaining in the terminal 5 input buffer to the console terminal, then outputs up to 2 question marks to the micro to get the * prompt from UT4. If the response is OK, ICLEAR=1, if not, ICLEAR=0.

IC2UP(ICO) — This function outputs the character contained in ICO to the micro, and sets IC2UP=1 if the first returned character is the same, otherwise IC2UP=0. The input buffer must be empty before calling IC2UP.

OUTCFG(IM,IUNIT,IWRITE) — This subroutine types out the array configuration table to unit IUNIT. OUTCFG is used for output to the console terminal, the configuration display and to the printer. If IWRITE is 0, then IUNIT is the terminal number. If IWRITE is 1, then IUNIT refers to the FORTRAN unit number.

XMIT(IM) — This subroutine transmits the array configuration table to the microprocessor, and tells it to set up the array.

E.2 Configuration-editing Subroutines

CONFIG(IM) — This subroutine allows the reconfiguration of the active hydrophones by allowing the number active and their hardwired numbers to be entered.

HYDCAL(IM) — This subroutine allows the choice of Hydrophone alone, or Hydrophone in series with a calibration signal.

HIGHPS(IM) — This subroutine allows the choice of using a high-pass filter or not.

LOWPAS(IM) — This subroutine allows the choice of using an anti-alias filter or not.

DUMMYC(IM) — This subroutine allows the choice of the Hydrophone, or a dummy capacitor.

FREQ(IM) — This subroutine allows changing the preamp gains to 18,24,30,36, or 42 dB, which also affects the high-pass frequency characteristics.

ATTEN(IM) — This subroutine allows changing the attenuators to 0,6,12,18,24,30,36, or 42 dB.

POTRNG(IM,ISTART,IEND) — This subroutine inputs the range of pots to be changed. ISTART is the first and IEND is the last pot to be changed.

GAIN(IM) This subroutine allows changing the post-amp gains and the pads to within the range of -36 to 84 dB.

E.3 Numerical-conversion Subroutines

H2I(IM,ISTART,INTEGR) This subroutine converts two ASCII hex digits starting at ISTART in IM into the integer number INTEGR.

I2H(IM,ISTART,INTEGR) This subroutine converts the integer number INTEGR into two ASCII hex digits which are placed in IM starting at ISTART.

Appendix F

Microprocessor Array-control Program UPCP4

```
        .PRINT
        .PAGE
*
*       CONTROL PROGRAM FOR HYDRA
*       10:37am  Friday, 10 June 1983
*
*               This version contains UPCP1 and UPCP3 plus additional
*       commands to bring the program up to date with the new LEU, pots
*       and receiver package.  First to be used on cruise Q111.
*
*       UT4 ENTRY POINTS
*
READ    =$813E          Input ascii into RF.1
READAH  =$813B          " and hex into RD from right, DF=1; else DF=0.
TYPE    =$81A4          Type ascii @RF.1
TYPE2   =$81AE          Type hex pair @RF.1
TYPE6   =$81A2          Type ascii immediate
*
STARTH  =<START>H
STARTL  =<START>L
STACKH  =<STACK>H
STACKL  =<STACK>L
CFIGH   =<CFIG>H
CFIGL   =<CFIG>L
CMANDH  =<CMAND>H
CMANDL  =<CMAND>L
CALLH   =<CALL>H
CALLL   =<CALL>L
RETL    =<RETURN>L
UL      =<U>L
LL      =<L>L
RL      =<R>L
HL      =<H>L
BL      =<B>L
SL      =<S>L
NL      =<N>L
ZL      =<Z>L
DL      =<D>L
PL      =<P>L
WL      =<W>L
GL      =<G>L
AL      =<A>L
HYL     =<HY>L
CL      =<C>L
B0L     =<B0>L
B1L     =<B1>L
B2L     =<B2>L
DMYL    =<DMY>L
HPYL    =<HPY>L
HPNL    =<HPN>L
DMYYL   =<DMYY>L
DMYNL   =<DMYN>L
LPYL    =<LPY>L
LPNL    =<LPN>L
        *=0
        .SPACE
        LDI     STARTH  Main program
```

```
        PHI     3       starts at
        LDI     STARTL  START
        PLO     3
        LDI     STACKH  High byte for
        PHI     2        stack
        LDI     STACKL  Low byte for
        PLO     2        stack bottom
        LDI     CMANDH  High byte for
        PHI     8        command sequence
        LDI     CFIGH   High byte for
        PHI     $A       pot configuration
        LDI     CALLH   High byte for
        PHI     4        CALL
        PHI     5        RETURN
        LDI     CALLL   Low byte for
        PLO     4        CALL
        LDI     RETL    Low byte for
        PLO     5        RETURN
        SEP     3       Main program counter is R3
START   SEP     4       Type [CR] [LF] @ [SPACE]
        .WORD   BLKTYP   "
        .WORD   COMAT    "
        .BYTE   4        "
        SEP     4       Branch subroutine
        .WORD   BRNG     "
        .BYTE   'U' UL 'L' LL 'R' RL 'H' HL
        .BYTE   'B' BL 'S' SL '#' NL 'P' PL
        .BYTE   'D' DL 'Z' ZL 0
        BR      START   Error. None of above
U       SEP     4       Type [T] [4]
        .WORD   BLKTYP   "
        .WORD   T4       "
        .BYTE   2        "
        SEP     4       Return to UT4
        .WORD   CHKCR   Check for [CR]
        BR      START   Error
        LDI     $80     Load R5 with 8039
        PHI     5        start of UT4
        LDI     $39      "
        PLO     5        "
        LBR     $812E   Branch to end of TIMALC
L       SEP     4       Type 'ow Freq'
        .WORD   BLKTYP   "
        .WORD   LOWF     "
        .BYTE   7        "
        SEP     4       Low frequency
        .WORD   CHKCR   Check for [CR]
        BR      START   Error
        SEX     3       Output 5        0000/0101
        OUT     2        to port 2
        .BYTE   5        "
        BR      START   Start for more
R       SEP     4       Type 'andom Noise'
        .WORD   BLKTYP   "
        .WORD   RAND     "
        .BYTE   11
        SEP     4       Random noise
        .WORD   CHKCR   Check for [CR]
        BR      START   Error
        SEX     3       Output 4        0000/0100
        OUT     2        to port 2
        .BYTE   4        "
```

```
        BR      START   Start for more
H       SEP     4       Type 'alt Cal'
        .WORD   BLKTYP   "
        .WORD   HALTC    "
        .BYTE   7
        SEP     4       Halt cal
        .WORD   CHKCR   Check for [CR]
        BR      START   Error
        SEX     3       Output 2        0000/0010
        OUT     2        to port 2
        .BYTE   2        "
        BR      START   Start for more
B       SEP     4       Type 'its/word'
        .WORD   BLKTYP   "
        .WORD   ITSWRD   "
        .BYTE   8
        SEP     4       Bits per word
        .WORD   NTRNO   Enter # to RD.1
        BR      START   Error
        SEX     2       Stack pointer
        GHI     $D      Get #
        STR     2       Store on stack
        OUT     6       Output to port 6
        DEC     2       Restore pointer
        BR      START   Start for more
S       SEP     4       Type 'eq/sync'
        .WORD   BLKTYP   "
        .WORD   EQSYNC   "
        .BYTE   7
        SEP     4       Sequences per sync
        .WORD   NTRNO   Enter # to RD.1
        BR      START   Error
        SEX     2       Stack pointer
        GHI     $D      Get #
        ORI     $40     Bit rate = 131072 * 4
        STR     2       Store on stack
        OUT     7       Output to port 7
        DEC     2       Restore pointer
        BR      START   Start for more
N       SEP     4       Type ' of channels'
        .WORD   BLKTYP   "
        .WORD   OFCHAN   "
        .BYTE   12
        SEP     4       # of channels
        .WORD   NTRNO   Enter # to RD.1
        BR      START   Error
        SEX     2       Stack pointer
        GHI     $D      Get #
        STR     2       Store on stack
        OUT     5       Output to port 5
        DEC     2       Restore pointer
        OUT     1       Output to port 1
        DEC     2       Restore pointer
        BR      START   Start for more
D       SEP     4       Type 'igitization rate'
        .WORD   BLKTYP   "
        .WORD   IGITIZ   "
        .BYTE   16
        SEP     4       Sampling rate = 8192/#
        .WORD   NTRNO   Enter # to RD.1
        BR      START   Error
        SEX     2       Stack pointer
```

```
        GHI     $D      Get #
        STR     2       Store on stack
        OUT     3       Output to port 3
        DEC     2       Restore pointer
        BR      START   Start for more
P       LBR     POT     Branch to next page
Z       SEP     4       Pot setup
        .WORD   CHKCR   Check for [CR]
        BR      START   Error
        LDI     CFIGL   Set RA to point at #of pots
        PLO     $A       in configuration table
        LDI     0       Zero R9.0
        PLO     9        "
COUT    INC     9       R9=R9+1
        INC     $A      Set RA at wired address
        LDI     CMANDH  Point R8 at
        PHI     8        storage
        LDI     CMANDL   bottom
        PLO     8        for command sequence
        SEX     8       Get pot wired
        LDN     $A       address
        PLO     7        into R7.0
        ORI     $C0     Add control bits for reset Q
        STXD            Store on command stack
        INC     $A      Point at H/C, atten, G0 byte
        LDN     $A      Load byte
        PHI     7       Put byte in R7.1
        ANI     $38     Mask atten
        ORI     2       Address of atten = 2
        STXD            Store on command stack
        LDN     $A      Reload byte
        ANI     7       Mask G0
        SHL             Shift left
        SHL              to put preamp gain
        SHL              in data location
        ORI     4       Address of preamp = 4
        STXD            Store on command stack
        INC     $A      Point at pad, G2, G1 byte
        LDN     $A      Load pad, G2, G1 byte
        ANI     $C0     Mask pad
        SHR             Shift pad attenuation
        SHR              into data
        SHR              position
        STR     8       Store on stack
        GHI     7       Get H/C, Atten, G0 byte
        ANI     $40     Mask H/C bit
        SHR             Shift to data position
        OR              Add pad bits
        STR     8       Store on stack
        GHI     7       Get H/C, Atten, G0 byte
        SHLC            Put filter bit into DF
        BDF     FILTIN  If DF = 1, filter in
        LDI     6       Address for filter out
        LSKP            Skip past FILTIN
FILTIN  LDI     3       Address for filter in
        OR              Add filter bit
        STXD            Store on command stack
        LDN     $A      Reload pad, G2, G1 byte
        ANI     $38     Mask G2
        ORI     1       Address of G2 = 1
        STXD            Store on command stack
        LDN     $A      Reload pad, G2, G1 byte
```

```
        ANI     7       Mask G1
        SHL             Shift left
        SHL              to put gain
        SHL              in data location
        STXD            Address of G1=0, store on stack
        INC     $A      Point at HYD or DUM, L.P. byte
        LDN     $A      Load byte
        ANI     7       Mask HYD or DUM, L.P.
        SHL             Shift left
        SHL              to put HYD or DUM, L.P.
        SHL              in data location
        ORI     5       Address of HYD or DUM, L.P. = 5
        STXD            Store on command stack
        GLO     7       Get wired address
        ORI     $80     Add bits for set Q
        STXD            Store on command stack
        GLO     9       Get logical pot #
        STXD            Store on command stack
        GLO     7       Get wired address
        ORI     $40     Set address bit
        STXD            Store on command stack
        LDI     10      Ten commands
        STR     8       Store on command stack
        SEP     4       Output commands
        .WORD   BUSOUT   to bus
        LDI     CFIGH   Set R8
        PHI     8        to point
        LDI     CFIGL    at #
        PLO     8        of pots
        GLO     9       Get logical pot #
        SEX     8       R8 is pointer
        SD              #of pots-logical pot#
        LBNZ    COUT    Go back for more pots
        LBR     START   Start for more
POT     SEP     4       Type 'ot #'
        .WORD   BLKTYP   "
        .WORD   POTNUM   "
        .BYTE   4
        SEP     4       Pot #
        .WORD   NTRNO   Enter # to RD.1
        LBR     START   Error
        GHI     $D      Get #
        PLO     9       Put in R9.0
        SHL             *2
        SHL             *2
        SMI     3       -3 to get offset in CFIG table
        ADI     CFIGL   Add base address of array config.
        PLO     $A      RA is present pot pointer
MOREP   SEP     4       Type [CR] [LF] > [SPACE]
        .WORD   BLKTYP   "
        .WORD   ARROW    "
        .BYTE   4        "
        LDI     CMANDL  Point R8 at storage bottom
        PLO     8        for command sequence
        SEX     8       Get pot wired
        LDN     $A       address
        ORI     $C0     Add control bits for reset Q
        STXD            Store on command stack
        SEP     4       Branch subroutine
        .WORD   BRNG     "
        .BYTE   'W' WL 'G' GL 'A' AL 'H' HYL
        .BYTE   'C' CL 'D' DMYL 0
```

```
         LBR     START   Error
W        SEP     4       Type 'ired #'
         .WORD   BLKTYP   "
         .WORD   WIREDN   "
         .BYTE   6
         SEP     4       Wired #
         .WORD   NTRNO   Enter #
         BR      MOREP   Error
         SEX     8       Command pointer
         GLO     9       Logical pot #
         STXD            Store on command stack
         GLO     $D      Get wired #
         STR     $A      Store in array config. memory
         ORI     $40     Add control bits for set address
         STXD            Store on command stack
         LDI     2       Two commands
ENDW     STR     8       Store on command stack
         SEP     4       Output commands
         .WORD   BUSOUT   to bus
         BR      MOREP   Branch for more
G        SEP     4       Branch subroutine
         .WORD   BRNG     "
         .BYTE   '0' B0L '1' B1L '2' B2L 0
         BR      MOREP   Error
B0       LDI     4       Set preamp address
         LSKP
B1       LDI     0       Set amp 1 address
         LSKP
B2       LDI     1       Set amp 2 address
         STR     8       Store on command stack
         SEP     $C      Delay of
         .BYTE   23       3 bit times
         SEP     4       Type a
         .WORD   TYPE6    comma
         .BYTE   ','      "
DECBEL   SEP     4       Type ' DB'
         .WORD   BLKTYP   "
         .WORD   DB       "
         .BYTE   3        "
         SEP     4       Enter #
         .WORD   NTRNO    "
         BR      MOREP   Error
         LDI     7       Put 7 into R0.0
         PLO     0        "
         GHI     $D      Get #
DBLP     BZ      ZERO    Go to ZERO if #=zero
         DEC     0       Increment R0
         SMI     6       Subtract 6 dB
         NOP
         NOP
         BNF     ERR     Error if # not multiple of 6
         BR      DBLP    Go to subtract 6 more
ERR      SEP     $C      Delay of
         .BYTE   23       3 bit times
         SEP     4       Type [LF]
         .WORD   TYPE6    "
         .BYTE   $A       "
         SEP     4       Type error
         .WORD   BEL      message
         BR      MOREP   Jump to more pot commands
ZERO     GLO     0       Get # of 6's that were subtracted
         SHL             Put data in correct
```

```
         SHL              location in command
         SHL              "
         SEX     8        Command pointer
         OR               Add address bits
         STXD             Store on command stack
FINI     LDN     $A       Get wired number
         ORI     $80      Add bits to make set Q
         STXD             Store on command stack
         LDI     3        Three commands
         BR      ENDW     Go back to output commands
A        SEP     4        Type 'tten'
         .WORD   BLKTYP    "
         .WORD   TTEN      "
         .BYTE   4
         LDI     2        Set attenuator address
         STR     8        Store on command stack
         BR      DECBEL   Go to enter dB
C        LBR     PG2C     Branch to next page
DMY      LBR     PG2DMY    "
HY       SEP     4        Type 'yd'
         .WORD   BLKTYP    "
         .WORD   YD        "
         .BYTE   2
         LDI     3        Set cal/pad address
SAME     STR     2        Store on general stack
         DEC     2        Decrement stack pointer
         SEP     4        Type ', H.P. filter (Y or N) ? '
         .WORD   BLKTYP    "
         .WORD   HPFILT    "
         .BYTE   25
         SEP     4        Branch subroutine
         .WORD   BRNG      "
         .BYTE   'Y' HPYL 'N' HPNL 0
         BR      SAME     Error.None of above
HPN      LDI     3        Adjust address for no filter
         LSKP
HPY      LDI     0
         SEX     2        Point at general stack
         IRX              Point at cal/pad address
         ADD              Adjust if necessary
         STR     8        Store on command stack
         SEP     4        Type ', pad dB'
         .WORD   BLKTYP    "
         .WORD   PADDB     "
         .BYTE   8
         SEP     4        Enter #
         .WORD   NTRNO     "
         LBR     MOREP    Error
         SEX     8        Command pointer
         GLO     $D       Get #
         BZ      C0       Go to C0 if 0
         XRI     $18      Go to C18
         BZ      C18       if 18
         GLO     $D       Get #
         XRI     $36      Go to C36
         BZ      C36       if 36
         LBR     ERR      Error
C18      DEC     8        Leave data 0 if 18 dB
         LBR     FINI     Go to complete command
C0       LDI     $10      Data 10 if 0 dB
         LSKP
C36      LDI     8        Data 8 if 36 dB
```

```
        OR              Add address bits
        STXD            Store on command stack
        LBR     FINI    Go to complete command
PG2C    LDI     $23     Set cal bits
        BR      SAME    Go to complete command
PG2DMY  SEP     4       Type 'ummy (Y or N) ? '
        .WORD   BLKTYP   "
        .WORD   UMMY     "
        .BYTE   16       "
        SEP     4       Branch subroutine
        .WORD   BRNG     "
        .BYTE   'Y' DMYYL 'N' DMYNL 0
        LBR     DMY     Error.None of above
DMYY    LDI     $D      Set dummy H/P bit and address
        LSKP
DMYN    LDI     5       Address for data
        STR     2       Put on general stack
        DEC     2       Set stack pointer
        SEP     4       Type ', L.P. filter (Y or N) ? '
        .WORD   BLKTYP   "
        .WORD   LPFILT   "
        .BYTE   25       "
        SEP     4       Branch subroutine
        .WORD   BRNG     "
        .BYTE   'Y' LPYL 'N' LPNL 0
        BR      DMYN    Error.None of above
LPN     LDI     $10     Set anti-alias filter bypass bit
        LSKP
LPY     LDI     0
        SEX     2       Use general stack pointer
        IRX             Point at dummy and address info
        OR              Combine info
        SEX     8       Point with command stack pointer
        STXD            Store on command stack
        LBR FINI        Go to complete command
*
*       Pot configuration table
*
CFIG    .BYTE   0       #of logical pots
        .BYTE   0 0 0 0 pot #1
        .BYTE   0 0 0 0 pot #2
        .BYTE   0 0 0 0 pot #3
        .BYTE   0 0 0 0 pot #4
        .BYTE   0 0 0 0 pot #5
        .BYTE   0 0 0 0 pot #6
        .BYTE   0 0 0 0 pot #7
        .BYTE   0 0 0 0 pot #8
        .BYTE   0 0 0 0 pot #9
        .BYTE   0 0 0 0 pot #10
        .BYTE   0 0 0 0 pot #11
        .BYTE   0 0 0 0 pot #12
        .BYTE   0 0 0 0 pot #13
        .BYTE   0 0 0 0 pot #14
        .BYTE   0 0 0 0 pot #15
        .BYTE   0 0 0 0 pot #16
        .BYTE   0 0 0 0 pot #17
        .BYTE   0 0 0 0 pot #18
        .BYTE   0 0 0 0 pot #19
        .BYTE   0 0 0 0 pot #20
        .BYTE   0 0 0 0 pot #21
        .BYTE   0 0 0 0 pot #22
        .BYTE   0 0 0 0 pot #23
```

```
        .BYTE   0 0 0 0 pot #24
        .BYTE   0 0 0 0 pot #25
        .BYTE   0 0 0 0 pot #26
        .BYTE   0 0 0 0 pot #27
        .BYTE   0 0 0 0 pot #28
        .BYTE   0 0 0 0 pot #29
        .BYTE   0 0 0 0 pot #30
        .BYTE   0 0 0 0 pot #31
        .BYTE   0 0 0 0 pot #32
*
*       Command buffer
*
        .BYTE   0 0 0 0 0
        .BYTE   0       10 commands
        .BYTE   0       wired address
        .BYTE   0       logical #
        .BYTE   0       set Q
        .BYTE   0       hyd/dum, L.P.
        .BYTE   0       G1
        .BYTE   0       G2
        .BYTE   0       cal/pad
        .BYTE   0       G0
        .BYTE   0       atten
CMAND   .BYTE   0       reset Q
*
*       Stack
*
        .BYTE   0 0 0 0 0 0 0 0
        .BYTE   0 0 0 0 0 0 0
STACK   .BYTE   0
*
*       VOCABULARY
*
COMAT   .BYTE   $0D $0A '@ '
T4      .BYTE   'T4'
LOWF    .BYTE   'ow Freq'
RAND    .BYTE   'andom '
        .BYTE   'Noise'
HALTC   .BYTE   'alt Cal'
ITSWRD  .BYTE   'its/word'
EQSYNC  .BYTE   'eq/sync'
OFCHAN  .BYTE   ' of chan'
        .BYTE   'nels'
IGITIZ  .BYTE   'igitizat'
        .BYTE   'ion rate'
POTNUM  .BYTE   'ot #'
ARROW   .BYTE   $0D $0A '> '
COLON   .BYTE   ':'
DB      .BYTE   ' DB'
QSTN    .BYTE   '?' $07
WIREDN  .BYTE   'ired #'
TTEN    .BYTE   'tten'
YD      .BYTE   'yd'
PADDB   .BYTE   ', pad dB'
HPFILT  .BYTE   ', H.P. f'
        .BYTE   'ilter (Y'
        .BYTE   ' or N) ?'
        .BYTE   ' '
UMMY    .BYTE   'ummy (Y '
        .BYTE   'or N) ? '
LPFILT  .BYTE   ', L.P. f'
        .BYTE   'ilter (Y'
```

```
        .BYTE   ' or N) ?'
        .BYTE   ' '
        .SPACE
*
*       SUBROUTINES FOR CP1
*       9:55am  Wednesday, 27 April 1983
*
*       Branching subroutine
*
BRNG    SEP     4       Enter ascii to RF.1
        .WORD   READAH   "
        SEX     6       R6 points at subroutine parameters
MTCHLP  GHI     $F      Get ascii
        XOR             Compare with parameter
        BZ      MATCH   Branch if match
        LDA     6       Pick up next parameter
        INC     6
        BNZ     MTCHLP  Loop if not 0
        SEP     4       Type error
        .WORD   BEL      "
        DEC     6
        SEP     5       Error return
MATCH   INC     6       Pick up next parameter
        LDA     6        for branch
        PLO     6        "
        SEP     5       Return
*
*       Check [CR] subroutine
*
CHKCR   GHI     $E      Get RE.1
        ORI     1       Set bit one for echo off
        PHI     $E      Replace
        SEP     4       Enter ascii
        .WORD   READAH   to RF.1
        GHI     $E      Get RE.1
        ANI     $FE     Reset bit one for echo on
        PHI     $E      Replace
CHK2    GHI     $F      Get ascii
        XRI     $D      XOR with [CR]
        BNZ     BEL     Branch to BEL if not [CR]
        INC     6       Skip error jump
        INC     6        in main routine
        SEP     5       Return
BEL     SEP     4       Type '?[BEL]'
        .WORD   BLKTYP   "
        .WORD   QSTN     "
        .BYTE   2        "
        SEP     5       Return
*
*       Enter number subroutine
*
*       RD.1 is the binary equivalent of the input 0 to 99 base 10.
*
NTRNO   SEP     4       Type': '
        .WORD   BLKTYP   "
        .WORD   COLON    "
        .BYTE   2        "
        LDI     0       Put 0
        PLO     $D       in RD.0
HEXLP   SEP     4       Read hex
        .WORD   READAH   into RD
        LBDF    HEXLP   Branch if hex read
```

```
        BNZ     BUSLP    not finished
        SEX     3       Program pointer
        OUT     4       Leave bus
        .BYTE   $FF      FF to port 4
        SEP     $C      Delay of
        .BYTE   1        0.4 bit times
        DEC     8       Return command pointer to bottom
        SEP     5       Return
*
*       Call subroutine
*
CLLP    SEP     3       Go to subroutine
CALL    SEX     2       Point to stack
        GHI     6       R6 to stack to prepare
        STXD             for pointing to
        GLO     6        arguments and decrement
        STXD             to free location
        GHI     3       R3 to R6
        PHI     6        to save
        GLO     3        return address
        PLO     6        "
        LDA     6       Load address of
        PHI     3        subroutine
        LDA     6        into R3
        PLO     3        "
        BR      CLLP    Reset call pointer
*
*       Return subroutine
*
RTNLP   SEP     3       Return to main program
RETURN  GHI     6       R6 to R3
        PHI     3        R3 contains
        GLO     6        the return address
        PLO     3        "
        SEX     2       Point to stack
        INC     2       Point to saved old R6
        LDXA            Restore contents
        PLO     6        of R6
        LDX              "
        PHI     6        "
        BR      RTNLP   Reset return pointer
        .SPACE
        .SPACE
        .END
```

Appendix G

Minicomputer Array-control Program CHYDRA

```
C-------------------------------------------------------DREA-SWA-STAAL----
      PROGRAM CHYDRA
C
C     Written by Philip Staal
C
C     LAST EDIT:      3:44pm  Monday, 16 May 1983
C
C     PURPOSE:        This program controls the HYDRA array through
C                   the terminal 5 connection, and lists the current array
C                   configuration on terminal 4.  It can print the Hydra
C                   configuration and appends each configuration upon
C                   Quitting the program into CHYDRA.LOG.
C
C     HARDWARE:       - terminal 5 connection to HYDRA array
C                     - terminal 4 connection to video terminal
C
C     SOFTWARE:       - gain file SY:CHYDRA.GAN
C                     - previous configuration file SY:CHYDRA.CFG
C                     - micro-processor files to be downloaded
C                     - file SY:CHYDRA.2DA
C                     - append file SY:CHYDRA.LOG
C
C     CONFIGURATION   BYTE #          PURPOSE
C     STORAGE
C     FORMAT          1       # of logical #'s
C                     2       Pot 1   wired #
C                     3       Pot 1   L.F.Rolloff,H/C,
C                                     atten,freq(preamp)
C                     4       Pot 1   gain(pad,G1,G2)
C                     5       Pot 1   hyd/dum,L.P. filt.
C                     6       Pot 2   wired #
C                     7       Pot 2   L.F. ...
C                     8       Pot 2   gain ...
C                     .         .       .
C                     .         .       .
C                     .         .       .
C
C     COMMON VIRTUAL ARRAY IM(32000)
C
C     IM(1) to IM(29999)      uP Dump Programs
C
C     IM(31000),IM(31001)='0','0' to '3','F'  # of logical #'s
C     IM(31002),IM(31003)='0','0' to '3','F'  wired #'s
C     IM(31004),IM(31005)='0','0' to 'F','F'  HP,H/C,atten,freq
C     IM(31006),IM(31007)='0','0' to 'F','F'  gain
C     IM(31008),IM(31009)='0','0' to 'F','F'  hyd/dum,L.P. filt.
C         .           .
C         .           .
C         .           .
C
C     IM(31500),IM(31501)     -36 dB in ASCII hex form
C     IM(31502),IM(31503)     -30 dB          "
C         .           .         .
C         .           .         .
C         .           .         .
C     IM(31540),IM(31541)      80 dB          "
C
```

```
C       IM(31600) = 1   If changes made to configuration table
C                       that have not been transmitted
C                 = 0   Otherwise
C
C       NOTE:   For 300 BAUD, <LF> takes 15.4 ticks, and any other
C               character takes 2.2 ticks. Sleep times are taken from
C               this, with a 5 tick safety margin.
C
        VIRTUAL IM(32000)
        COMMON/TERS/SBLOK               ! terminal status block
        BYTE IM
        IM(31600)=0                     ! No changes to xmit
C
C       Read in optimum gain table, and last array configuration
C
        OPEN(UNIT=2,NAME='SY:CHYDRA.GAN',READONLY,TYPE='OLD')
        DO 10 I=1,41,2
10        READ(2,10020)IM(31499+I),IM(31500+I)
        CLOSE(UNIT=2)
        OPEN(UNIT=2,NAME='SY:CHYDRA.CFG',TYPE='OLD')
        READ(2,10020)IM(31000),IM(31001)
        CALL H2I(IM,31000,NP)   ! Get number of pots in config.: NP
        DO 20 J=1,NP
          L=31002+(J-1)*8
20        READ(2,10030)IM(L),IM(L+1),IM(L+2),IM(L+3),IM(L+4),IM(L+5),IM(L+
        16),IM(L+7)
        CLOSE(UNIT=2)
C
C       Type command list and look for commands
C
        CALL QSTN
30      TYPE 10040
        ACCEPT 10050,CMD
        IF(CMD.EQ.'A')CALL ATTEN(IM)
        IF(CMD.EQ.'C')CALL CONFIG(IM)
        IF(CMD.EQ.'D')CALL DIRECT(5)
        IF(CMD.EQ.'F')CALL FREQ(IM)
        IF(CMD.EQ.'G')CALL GAIN(IM)
        IF(CMD.EQ.'H')CALL HYDCAL(IM)
        IF(CMD.EQ.'I')CALL DUMMYC
        IF(CMD.EQ.'L')CALL DOWNLD(IM)
        IF(CMD.EQ.'P')CALL OUTCFG(IM,6,1)
        IF(CMD.EQ.'Q')CALL QUIT(IM)
        IF(CMD.EQ.'T')CALL OUTCFG(IM,0,0)
        IF(CMD.EQ.'U')CALL LOWPAS(IM)
        IF(CMD.EQ.'W')CALL HIGHPS(IM)
        IF(CMD.EQ.'X')CALL XMIT(IM)
        IF(CMD.EQ.'A'.OR.CMD.EQ.'C'.OR.CMD.EQ.'D')GO TO 30
        IF(CMD.EQ.'F'.OR.CMD.EQ.'G'.OR.CMD.EQ.'H')GO TO 30
        IF(CMD.EQ.'I'.OR.CMD.EQ.'L'.OR.CMD.EQ.'P')GO TO 30
        IF(CMD.EQ.'Q'.OR.CMD.EQ.'T'.OR.CMD.EQ.'U')GO TO 30
        IF(CMD.EQ.'W'.OR.CMD.EQ.'X')GO TO 30
C
C       Type menu if command is not recognized
C
        CALL QSTN
        GO TO 30
C
10010   FORMAT(I4)
10020   FORMAT(2A1)
10030   FORMAT(8A1)
10040   FORMAT(/4X,'COMMAND ? '$)
```

```
10050   FORMAT(A1)
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE QSTN
C
C               This subroutine types the list of parameters and
C       available commands on the console terminal.
C
        TYPE 10010
        RETURN
C
10010   FORMAT(/4X,'? = List of available commands'/
        1 4X,'Q = Quit back to monitor'/
        2 4X,'A = Attenuator change'/
        3 4X,'C = Configuration of array change'/
        4 4X,'D = Direct connection of terminal to microprocessor'/
        5 4X,'F = Frequency response (preamp gain) change'/
        6 4X,'G = Gain of post amps change'/
        7 4X,'H = Hydrophone or Cal change'/
        8 4X,'I = Input hydrophone or capacitor change'/
        9 4X,'L = Load microprocessor from PDP11 disk file'/
        1 4X,'P = Print array configuration table'/
        2 4X,'T = Type array configuration table'/
        3 4X,'U = Upper frequencies (anti-alias filter) change'/
        4 4X,'W = High-pass filter change'/
        5 4X,'X = Transmit and setup array configuration')
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE QUIT(IM)
C
C               This subroutine returns to the monitor in a graceful
C       fashion.  It stores the current configuration in CHYDRA.CFG,
C       appends the configuration to CHYDRA.LOG, and outputs the
C       information to CHYDRA.2DA for the data acquisition programs.
C
        VIRTUAL IM(32000)
        BYTE IM,LABEL(512),CHAR
        INTEGER*2 DBLK(4)
        DATA LABEL/512*0/                ! data for CHYDRA.2DA
        DATA DBLK/3RSY ,3RCHY,3RDRA,3R2DA/ ! SY:CHYDRA.2DA is out file
C
        IF(IM(31600).EQ.1)TYPE 10020     ! Warn if config. not xmitted
C
C       Ask if really want to quit
C
        TYPE 10030
        ACCEPT 10040,YESNO
        IF(YESNO.NE.'Y')RETURN
C
C       Store last array config. in SY:CHYDRA.CFG, and in SY:CHYDRA.2DA
C
        TYPE 10110
        OPEN(UNIT=2,NAME='SY:CHYDRA.CFG',TYPE='UNKNOWN',
        1CARRIAGECONTROL='LIST')
        ICHAN=IGETC()
        IF(ICHAN.LT.0)STOP '*** NO CHANNEL IN QUIT ***'
        IF(IFETCH(DBLK).NE.0)STOP '*** BAD FETCH IN QUIT ***'
        IF(IENTER(ICHAN,DBLK,1).LT.0)STOP '*** BAD IENTER IN QUIT ***'
        WRITE(2,10050)IM(31000),IM(31001)        ! write hex # of pots
        CALL H2I(IM,31000,NP)
C
C       Loop over all pots
```

```
C
        LABEL(1)=NP                          ! Number of pots
10      DO 40 I=1,NP
          IPOT=4*I-2
          L=31002+(I-1)*8
          CALL H2I(IM,L,NW)                  ! wired number
          CALL H2I(IM,L+2,NHC)               ! HiPass,H/C,atten,preamp
          CALL H2I(IM,L+4,NG)                ! gain(pad,G1,G2)
          CALL H2I(IM,L+6,NDUM)              ! hyd/dum,L.P. filt.
          DO 20 J=2,42,2
            CALL H2I(IM,31498+J,NTST)
20          IF(NG.EQ.NTST)GO TO 30
30        NG=J*3-42                          ! Post amp and pad gain
          IGPRE=(7-(NHC.AND."7))*6           ! Preamp gain
          NGT=NG+IGPRE                       ! Total gain
          LABEL(IPOT)=NW                     ! Wired number
          LABEL(IPOT+1)=NGT
          LABEL(IPOT+2)=IGPRE/6+48           ! Pre-amp gain / 6 (dB)
          IPCODE=65+(NDUM.AND."3)+(NHC.AND."200)/32+(NHC.AND."100)/4
          LABEL(IPOT+3)=IPCODE               ! ASCII pot-code
40        WRITE(2,10060)IM(L),IM(L+1),IM(L+2),IM(L+3),IM(L+4),IM(L+5),
        1IM(L+6),IM(L+7)                     ! write to CHYDRA.CFG
        ICODE=IWRITW(256,LABEL,0,ICHAN)      ! write to CHYDRA.2DA
        IF(ICODE.LT.0)STOP '*** BAD IWRITW IN QUIT ***'
        CALL CLOSEC(ICHAN)
        CALL IFREEC(ICHAN)
        CLOSE(UNIT=2)
C
C       Append the configuration to SY:CHYDRA.LOG.
C
        TYPE 10100
50      OPEN(UNIT=2,NAME='SY:CHYDRA.LOG',TYPE='OLD',
        1CARRIAGECONTROL='FORTRAN',ERR=60)
        GO TO 80
C
C       If no file exists, create one of NBLOKS blocks
C
60      NBLOKS=150
        TYPE 10080,NBLOKS/10
        OPEN(UNIT=2,NAME='SY:CHYDRA.LOG',TYPE='NEW',
        1CARRIAGECONTROL='FORTRAN',INITIALSIZE=NBLOKS)
        WRITE(2,10070)
        DO 70 I=1,NBLOKS-1
70        WRITE(2,10090)      ! blank out the file so RT11 keeps its size
        CLOSE(UNIT=2)
        GO TO 50
C
C       Find end of file
C
80      READ(2,10040,END=100,ERR=100)CHAR
        IF(CHAR.EQ.'>')GO TO 90
        GO TO 80
C
C       Output configuration
C
90      BACKSPACE 2
100     CALL OUTCFG(IM,2,1)
        WRITE(2,10070,ERR=110,END=110)
        CLOSE(UNIT=2)
        STOP 'End of program CHYDRA'
110     STOP 'CHYDRA.LOG full.  Rename it,
        1 then RUN CHYDRA and Quit again.'
```

```
C
10010   FORMAT(I4)
10020   FORMAT(/4X,'<<< Configuration Table Changes Not Transmitted
        1 >>>')
10030   FORMAT(/4X,'STOP --- ARE YOU SURE ? (Y/N) '$)
10040   FORMAT(A1)
10050   FORMAT(2A1)
10060   FORMAT(8A1)
C
C       End of log file marker
C
10070   FORMAT(1X/1X/' >>> END OF LOG FILE ==========================')
C
C       Informative messages and blank block
C
10080   FORMAT(/4X,'Creating CHYDRA.LOG file.  Wait',I3,' seconds.'/)
10090   FORMAT(1X,126X,3(/1X,126X))
10100   FORMAT(/4X,'Appending configuration to CHYDRA.LOG file.'/)
10110   FORMAT(/4X,'Storing configuration in CHYDRA.CFG and CHYDRA.2DA')
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE DIRECT(ITER)
C
C               This subroutine connects the console terminal directly to
C       ITER. To pass out of direct mode, type two control-C's in a row.
C
        BYTE ICHAR,ICPO
C
        IFLAG=0
        ICPO=0                      ! previous output character
C
C       Set up terminal characteristics
C
        CALL SCCA(IFLAG)            ! stop intercepting control-C
        CALL SETTER(0,2)
        CALL SETTER(ITER,2)
C
C       Send characters from console to iter
C
10      IGOT1=MTIN(0,ICHAR)
        IF(IGOT1.NE.0)GO TO 30  ! if no console character, check iter
        IF(ICHAR.EQ.3.AND.ICPO.EQ.3)GO TO 50 ! quit if double control-C
20      ITST=MTOUT(ITER,ICHAR)
        IF(ITST.EQ.1)GO TO 20
        ICPO=ICHAR
C
C       Send characters from iter to console
C
30      IGOT1=MTIN(ITER,ICHAR)
        IF(IGOT1.NE.0)GO TO 10  ! if no iter character, check console
40      ITST=MTOUT(0,ICHAR)
        IF(ITST.EQ.1)GO TO 40
        GO TO 30
C
C       Reset terminal characteristics
C
50      CALL SCCA
        CALL SETTER(0,0)
        CALL SETTER(ITER,0)
        RETURN
        END
C-------------------------------------------------------DREA-SWA-STAAL----
```

```
      SUBROUTINE SETTER(UNIT,OPEN)
C
C             This subroutine attaches the terminal UNIT and normally
C     sets it for no echo, no wait, tab, form, no CR LF on carriage
C     limit, handle XON/XOFF, no handle ↑F,↑B,↑X, and pass all out if
C     OPEN = 1.  Pass all in is set if OPEN = 2. If OPEN = 0, then
C     the terminal UNIT is reset to the initial characteristics and
C     detached. If UNIT = 5, the FSK xmit is turned on and ASCII xmit
C     is enabled for OPEN.NE.0, and the FSK xmit is turned off and
C     data xmit is enabled for OPEN = 0.  The baud rate is normally
C     set to 300 baud.  However, if UNIT = 4, then the baud rate is
C     set to 9600 baud.
C
      INTEGER*2 SBLOK(4,6,2),UNIT,OPEN
C
      IZERO=0
      IF(OPEN.EQ.0)GO TO 20
C
C     Set the following on OPEN.NE.0
C
      IER=MTATCH(UNIT,0,JOB)
      IF(IER.NE.0)STOP '*** MTATCH ERROR IN SETTER ***'
      IER=MTGET(UNIT,SBLOK(1,UNIT+1,1))
      IF(IER.NE.0)STOP '*** MTGET ERROR IN SETTER ***'
      DO 10 I=1,4                ! save the terminal characteristics
10      SBLOK(I,UNIT+1,2)=SBLOK(I,UNIT+1,1)
      SBLOK(1,UNIT+1,1)="152705
      SBLOK(2,UNIT+1,1)="100006
      IF(UNIT.EQ.4)SBLOK(1,UNIT+1,1)="157305  ! set for display
      IF(OPEN.EQ.2)SBLOK(2,UNIT+1,1)="100206  ! read pass all too
      IER=MTSET(UNIT,SBLOK(1,UNIT+1,1))
      IF(IER.NE.0)STOP '*** MTSET ERROR IN SETTER ***'
      CALL RCTRLO
      IF(UNIT.NE.5)RETURN
C     CALL IPOKE("176510,"4.OR.IPEEK("176510))    ! Used for TT2:
      CALL IPOKE("160114,"2000.OR.IPEEK("160114)) ! Turn on FSK xmit
      ISEC=1
      ITICK=5
      CALL ISLEEP(IZERO,IZERO,ISEC,IZERO)     ! Wait for xmitter
      IT=MTOUT(UNIT,22)                  ! Output ↑V for xmit ASCII
      CALL ISLEEP(IZERO,IZERO,IZERO,ITICK)    ! Wait for switch
      RETURN
C
C     Reset the following if OPEN = 0
C
20    IF(UNIT.NE.5)GO TO 30
      IT=MTOUT(UNIT,20)                ! Output ↑T for xmit data
      ITICK=5
      CALL ISLEEP(IZERO,IZERO,IZERO,ITICK)
C     CALL IPOKE("176510,.NOT."4.AND.IPEEK("176510))!Turn off FSK xmit
      CALL IPOKE("160114,.NOT."2000.AND.IPEEK("160114))
30    DO 40 I=1,4                ! restore the terminal characteristics
40      SBLOK(I,UNIT+1,1)=SBLOK(I,UNIT+1,2)
      IER=MTSET(UNIT,SBLOK(1,UNIT+1,1))
      IF(IER.NE.0)STOP '*** MTSET ERROR IN SETTER ***'
      IER=MTDTCH(UNIT)
      IF(IER.NE.0)STOP '*** MTDTCH ERROR IN SETTER ***'
      RETURN
      END
C-------------------------------------------------------DREA-SWA-STAAL----
      SUBROUTINE DOWNLD(IM)
C
```

```
C               This subroutine asks for a single dump disk file, which
C       is then downline loaded to the micro-processor.
C
        VIRTUAL IM(32000)
        BYTE IM,MSTART(7)
        INTEGER*2 IFSPEC(39)            ! input file specifications
        REAL*4 EXT(2)
        DATA EXT/6RDMPDAT,6RDATDAT/     ! DMP is default file type
C
C       Get the input file name
C
        TYPE 10010
10      IF(ICSI(IFSPEC,EXT,,,0).NE.0)GO TO 10
C
C       Input the file to array IM
C
        CALL FILEIN(IFSPEC,1,IM,NCHAR)
C
C       NCHAR characters of dump data have been input.
C       Now put the uP loading address in MSTART
C
        DO 20 I=1,6
20        MSTART(I)=IM(I)
        MSTART(7)=' '
C
C       Open the link to the micro, transmit the dump data, close link
C
        CALL SETTER(5,1)
        CALL LOAD(7,NCHAR,MSTART,IM)
        CALL SETTER(5,0)
        RETURN
C
10010   FORMAT(/4X,'INPUT FILE NAME ? '$)
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE FILEIN(IFNAME,ISTART,IM,NCHAR)
C
C               This subroutine inputs and converts to LOAD format, the
C       disk dump file specified by IFNAME, into the virtual array IM,
C       starting at IM(ISTART).  The number of elements read into IM
C       is NCHAR.  This subroutine is used by DOWNLD to get the dump
C       file off disk.
C
        VIRTUAL IM(32000)
        BYTE IM,LINE(80)
        INTEGER*2 IFNAME(39)
C
C       Open the input file
C
        CALL IASIGN(2,IFNAME(16),IFNAME(17),0,32)
        I=ISTART
C
C       Read and translate line by line to end of file,
C       ignoring blanks and skipping memory line-headers.
C
10      READ(2,10010,END=40)(LINE(J),J=1,80)
        K=6
        IF(I.EQ.ISTART)K=1
20      IF(LINE(K).EQ.' ')GO TO 30
        IF(LINE(K).EQ.';')GO TO 10
        IM(I)=LINE(K)
        I=I+1
```

```
30      K=K+1
        IF(K.GT.80)GO TO 50
        GO TO 20
C
C       Close file and return
C
40      NCHAR=I-1
        CLOSE(UNIT=2)
        RETURN
50      TYPE *,'*** ERROR READING FILE IN FILEIN ***'
        I=NSTART
        GO TO 40
C
10010   FORMAT(80A1)
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE LOAD(ISTART,ISTOP,MSTART,IM)
C
C               This subroutine takes the memory image for the
C       microprocessor stored from IM(ISTART) to IM(ISTOP), and downline
C       loads it starting at the micro address specified by MSTART.
C
        VIRTUAL IM(32000)
        BYTE IM,MSTART(7),ICHAR
C
        IZERO=0
C
C       Get micro's prompt character *
C
        IF(ICLEAR().NE.1)RETURN
C
C       Tell micro where to put code
C
        DO 10 I=1,7
10        IF(IC2UP(MSTART(I)).NE.1)RETURN
C
C       Send code to micro, then <CR>
C
        DO 20 J=ISTART,ISTOP
20        IF(IC2UP(IM(J)).NE.1)RETURN
        IF(IC2UP(13).NE.1)RETURN
C
C       Wait 26 ticks, then check for error or prompt
C
        ITICK=26
        CALL ISLEEP(IZERO,IZERO,IZERO,ITICK)
30      IGOT1=MTIN(5,ICHAR)
        IF(ICHAR.EQ.'?')GO TO 40
        IF(IGOT1.EQ.0)GO TO 30
        IF(ICHAR.EQ.'*')RETURN
        TYPE *,'*** NO RESPONSE FROM UT4 IN LOAD ***'
        RETURN
C
40      TYPE *,'*** UNRECOGNIZED BY UT4 IN LOAD ***'
        RETURN
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        FUNCTION ICLEAR
C
C               This function outputs anything remaining in the terminal
C       5 input buffer to the console terminal, then outputs up to 2
C       question marks to the micro to get the * prompt from UT4. If the
```

```
C       response is OK,  ICLEAR=1,  if not,  ICLEAR=0.
C
        BYTE ICHAR,ICPI
C
        IZERO=0
        ICLEAR=1
        ICPI=0                  ! previous input character
        CALL RCTRLO             ! reset the control-O terminal command
C
C       Output anything remaining in input buffer to the console
C
10      IGOT1=MTIN(5,ICHAR)
        IF(IGOT1.NE.0)GO TO 40
        IF(ICHAR.NE.10)GO TO 20
        IF(ICPI.EQ.13)GO TO 30
20      ITST=MTOUT(0,ICHAR)             ! display on the console
        IF(ITST.EQ.1)GO TO 20
30      ICPI=ICHAR
        GO TO 10
C
C       Output up to 2 question marks and look for prompt
C
40      ITICK=48
        DO 70 I=1,2
50        ITST=MTOUT(5,'?')
          IF(ITST.EQ.1)GO TO 50
          CALL ISLEEP(IZERO,IZERO,IZERO,ITICK)
60        IGOT1=MTIN(5,ICHAR)
          IF(IGOT1.EQ.0)GO TO 60
70        IF(ICHAR.EQ.'*')RETURN
        TYPE *,'*** NO RESPONSE FROM UT4 IN ICLEAR ***'
        ICLEAR=0
        RETURN
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        FUNCTION IC2UP(ICO)
C
C               This function outputs the character contained in ICO to
C       the micro, and sets IC2UP=1 if the first returned character is
C       the same, otherwise IC2UP=0. The input buffer must be empty
C       before calling IC2UP.
C
        BYTE ICO,ICI
C
C       Output character ICO
C
        IC2UP=0
10      ITST=MTOUT(5,ICO)
        IF(ITST.EQ.1)GO TO 10
C
C       Check up to 10000 times for a response
C
        DO 20 I=1,10000
          IGOT1=MTIN(5,ICI)
20        IF(IGOT1.EQ.0)GO TO 30
C
C       If no response, say so and return
C
        TYPE *,'*** NO RESPONSE FROM MICRO IN IC2UP ***'
        RETURN
C
C       Check to see if the response matches what was sent
```

```
C
30      IF(ICI.NE.ICO)GO TO 40
        IC2UP=1
        RETURN
C
C       If response doesn't match, say so and give the ADE numbers
C
40      TYPE *,'*** MICRO ECHOED WRONG CHARACTER IN IC2UP ***'
        IICI=ICI
        IICO=ICO
        TYPE 10010,IICI,IICO
        RETURN
C
10010   FORMAT(9X,'Sent: ',I3,', Returned: ',I3)
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE H2I(IM,ISTART,INTEGR)
C
C               This subroutine converts two ASCII hex digits starting
C       at ISTART in IM into the integer number INTEGR.
C
        VIRTUAL IM(32000)
        BYTE IM
C
        N1=IM(ISTART)-48
        N2=IM(ISTART+1)-48
        IF(N1.GT.9)N1=N1-7
        IF(N2.GT.9)N2=N2-7
        INTEGR=N1*16+N2
        RETURN
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE I2H(IM,ISTART,INTEGR)
C
C               This subroutine converts the integer number INTEGR into
C       two ASCII hex digits which are placed in IM starting at ISTART.
C
        VIRTUAL IM(32000)
        BYTE IM
C
        N1=INTEGR/16
        N2=INTEGR-(N1*16)
        IF(N1.GT.9)N1=N1+7
        IF(N2.GT.9)N2=N2+7
        IM(ISTART)=N1+48
        IM(ISTART+1)=N2+48
        RETURN
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE CONFIG(IM)
C
C               This subroutine allows the reconfiguration of the active
C       hydrophones by allowing the number active and their hardwired
C       numbers to be entered.
C
        VIRTUAL IM(32000)
        BYTE IM
C
        IM(31600)=1                         ! Changes to xmit
C
C       Get number of pots and put in configuration storage
C
```

```
10      TYPE 10010
        ACCEPT *, NP
        IF(NP.LT.1.OR.NP.GT.64)GO TO 10
        CALL I2H(IM, 31000, NP)
C
C       Get wired numbers of pots and put in configuration storage
C
        DO 30 I=1, NP
20        TYPE 10020, I
          ACCEPT *, NW
          IF(NW.LT.1.OR.NW.GT.64)GO TO 20
          LOCN=31002+(I-1)*8
30        CALL I2H(IM, LOCN, NW)
C
C       Type the revised array configuration on the console
C
        CALL OUTCFG(IM, 0, 0)
        RETURN
C
10010   FORMAT(/4X, 'NUMBER OF POTS ? '$)
10020   FORMAT(/4X, 'POT #', I3, ': WIRED # ? '$)
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE HYDCAL(IM)
C
C               This subroutine allows the choice of Hydrophone alone,
C       or Hydrophone in series with a calibration signal.
C
        VIRTUAL IM(32000)
        BYTE IM, IH
C
C       Get the sequence numbers of the pots to be changed
C
        CALL POTRNG(IM, ISTART, IEND)
C
C       Ask if hydrophone or cal required
C
10.     TYPE 10010
        ACCEPT 10020, IH
        IF(IH.NE.'H'.AND.IH.NE.'C')GO TO 10
C
C       Put the hyd/cal information in configuration storage
C
        DO 20 I=ISTART, IEND
          LOCN=31004+(I-1)*8
          CALL H2I(IM, LOCN, NHC)
          IF(IH.EQ.'H')NHC=.NOT."100.AND.NHC
          IF(IH.EQ.'C')NHC="100.OR.NHC
20        CALL I2H(IM, LOCN, NHC)
C
C       Type the revised array configuration on the console
C
        CALL OUTCFG(IM, 0, 0)
        RETURN
C
10010   FORMAT(/4X, 'HYDROPHONE (H) OR CAL (C) ? '$)
10020   FORMAT(A1)
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE HIGHPS(IM)
C
C               This subroutine allows the choice of having a high-pass
```

```
C       filter.
C
        VIRTUAL IM(32000)
        BYTE IM, IH
C
C       Get the sequence numbers of the pots to be changed
C
        CALL POTRNG(IM, ISTART, IEND)
C
C       Ask if high-pass filter required
C
10      TYPE 10010
        ACCEPT 10020, IH
        IF(IH.NE.'I'.AND.IH.NE.'O')GO TO 10
C
C       Put the high-pass information in configuration storage
C
        DO 20 I=ISTART, IEND
          LOCN=31004+(I-1)*8
          CALL H2I(IM, LOCN, NHC)
          IF(IH.EQ.'O')NHC=.NOT."200.AND.NHC
          IF(IH.EQ.'I')NHC="200.OR.NHC
20        CALL I2H(IM, LOCN, NHC)
C
C       Type the revised array configuration on the console
C
        CALL OUTCFG(IM, 0, 0)
        RETURN
C
10010   FORMAT(/4X,'HIGHPASS IN (I) OR OUT (O) ? '$)
10020   FORMAT(A1)
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE LOWPAS(IM)
C
C               This subroutine allows the choice of having an
C       anti-alias filter.
C
        VIRTUAL IM(32000)
        BYTE IM, IL
C
C       Get the sequence numbers of the pots to be changed
C
        CALL POTRNG(IM, ISTART, IEND)
C
C       Ask if anti-alias filter required
C
10      TYPE 10010
        ACCEPT 10020, IL
        IF(IL.NE.'I'.AND.IL.NE.'O')GO TO 10
C
C       Put the anti-alias information in configuration storage
C
        DO 20 I=ISTART, IEND
          LOCN=31008+(I-1)*8
          CALL H2I(IM, LOCN, NDUM)
          IF(IL.EQ.'I')NDUM=.NOT."2.AND.NDUM
          IF(IL.EQ.'O')NDUM="2.OR.NDUM
          NDUM="3.AND.NDUM
20        CALL I2H(IM, LOCN, NDUM)
C
C       Type the revised array configuration on the console
```

```
C
        CALL OUTCFG(IM, 0, 0)
        RETURN
C
10010   FORMAT(/4X,'ANTI-ALIAS FILTER IN (I) OR OUT (O) ? '$)
10020   FORMAT(A1)
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE DUMMYC(IM)
C
C               This subroutine allows the choice of the Hydrophone,
C       or a dummy capacitor.
C
        VIRTUAL IM(32000)
        BYTE IM, ID
C
C       Get the sequence numbers of the pots to be changed
C
        CALL POTRNG(IM, ISTART, IEND)
C
C       Ask if hydrophone or dummy required
C
10      TYPE 10010
        ACCEPT 10020, ID
        IF(ID.NE.'H'.AND.ID.NE.'D')GO TO 10
C
C       Put the hyd/dum information in configuration storage
C
        DO 20 I=ISTART, IEND
          LOCN=31008+(I-1)*8
          CALL H2I(IM, LOCN, NDUM)
          IF(ID.EQ.'H')NDUM=.NOT."1.AND.NDUM
          IF(ID.EQ.'D')NDUM="1.OR.NDUM
          NDUM="3.AND.NDUM
20        CALL I2H(IM, LOCN, NDUM)
C
C       Type the revised array configuration on the console
C
        CALL OUTCFG(IM, 0, 0)
        RETURN
C
10010   FORMAT(/4X,'HYDROPHONE (H) OR DUMMY (D) ? '$)
10020   FORMAT(A1)
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE FREQ(IM)
C
C               This subroutine allows changing the preamp gains
C       to 18, 24, 30, 36, or 42 dB, which also affects the high-pass
C       characteristics.
C
        VIRTUAL IM(32000)
        BYTE IM
C
C       Get the sequence numbers of the pots to be changed
C
        CALL POTRNG(IM, ISTART, IEND)
C
C       Ask for the preamp gain
C
10      TYPE 10010
        ACCEPT *, NF
```

```
        IF(NF-NF/6*6.NE.0)GO TO 10      ! Must be multiple of 6
        NF=NF/6
        IF(NF.LT.3.OR.NF.GT.7)GO TO 10  ! Must be 18 to 42 dB
C
C       Put the preamp gain in configuration storage
C
        NF=7-NF
        DO 20 I=ISTART,IEND
          LOCN=31004+(I-1)*8
          CALL H2I(IM,LOCN,NHC)
          NHC=(%170.AND.NHC).OR.NF
20        CALL I2H(IM,LOCN,NHC)
C
C       Type the revised array configuration on the console
C
        CALL OUTCFG(IM,0,0)
        RETURN
C
10010   FORMAT(/4X,'PREAMP GAIN (dB):  (18,24,30,36,42) ? '$)
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE ATTEN(IM)
C
C               This subroutine allows changing the attenuators
C       to 0,6,12,18,24,30,36,  or 42 dB.
C
        VIRTUAL IM(32000)
        BYTE IM
C
C       Get the sequence numbers of the pots to be changed
C
        CALL POTRNG(IM,ISTART,IEND)
C
C       Ask for the attenuation
C
10      TYPE 10010
        ACCEPT *,NAT
        IF(NAT-NAT/6*6.NE.0)GO TO 10    ! Must be multiple of 6
        IF(NAT.LT.0.OR.NAT.GT.42)GO TO 10 ! Must be between 0 and 42 dB
C
C       Put the attenuation in configuration storage
C
        NAT=(7-NAT/6)*8
        DO 20 I=ISTART,IEND
          LOCN=31004+(I-1)*8
          CALL H2I(IM,LOCN,NHC)
          NHC=(%107.AND.NHC).OR.NAT
20        CALL I2H(IM,LOCN,NHC)
C
C       Type the revised array configuration on the console
C
        CALL OUTCFG(IM,0,0)
        RETURN
C
10010   FORMAT(/4X,'ATTENUATOR (dB):  (0,6,12,18,24,30,36,42) ? '$)
        END
C-------------------------------------------------------DREA-SWA-STAAL----
        SUBROUTINE POTRNG(IM,ISTART,IEND)
C
C               This subroutine inputs the range of pots to be changed.
C       ISTART is the first and IEND is the last pot to be changed.
C
```

```
      VIRTUAL IM(32000)
      BYTE IM
C
      IM(31600)=1                        ! Changes to xmit
      CALL H2I(IM,31000,NP)
10    TYPE 10010
      ACCEPT *,ISTART,IEND
      IF(ISTART.LT.1.OR.ISTART.GT.IEND)GO TO 10
      IF(IEND.GT.NP)GO TO 10
      RETURN
C
10010 FORMAT(/4X,'START POT, END POT ? '$)
      END
C-------------------------------------------------------DREA-SWA-STAAL----
      SUBROUTINE GAIN(IM)
C
C             This subroutine allows changing the post-amp gains and
C     the pads to within the range of -36 to 84 dB.
C
      VIRTUAL IM(32000)
      BYTE IM
C
C     Get the sequence numbers of the pots to be changed
C
      CALL POTRNG(IM,ISTART,IEND)
C
C     Ask for the gain excluding the preamp
C
10    TYPE 10010
      ACCEPT *,NG
      NG=NG+36
      IF(NG-NG/6*6.NE.0)GO TO 10       ! Must be multiple of 6
      IF(NG.LT.0.OR.NG.GT.120)GO TO 10 ! must be between -36 and 84 dB
C
C     Put the gain in configuration storage
C
      NG=NG/3
      NG1=IM(31500+NG)
      NG2=IM(31501+NG)
      DO 20 I=ISTART,IEND
        LOCN=31006+(I-1)*8
        IM(LOCN)=NG1
20      IM(LOCN+1)=NG2
C
C     Type the revised array configuration on the console
C
      CALL OUTCFG(IM,0,0)
      RETURN
C
10010 FORMAT(/4X,'GAIN (dB):'/' (-36,-30,-24,-18,-12,-6,0,6,12,18,24,
      130,36,42,48,54,60,66,72,78,84) ? '$)
      END
C-------------------------------------------------------DREA-SWA-STAAL----
      SUBROUTINE OUTCFG(IM,IUNIT,IWRITE)
C
C             This subroutine types out the array configuration table
C     to unit IUNIT.  If IWRITE is 0, then IUNIT is the terminal
C     number.  If IWRITE is 1, then IUNIT refers to the FORTRAN unit
C     number.
C
      VIRTUAL IM(32000)
      BYTE IM,LINE(80),BLANK(2)
```

```
      REAL*4 HC,HD,HIO,LIO
C
      DATA BLANK/' ',0/
C
      IZERO=0
C
CC    Read the time from the time code generator for output
C
      CALL READTC(IID,IIH,IIM,IIS,IIMS)
      IHZ=IIH
      IMZ=IIM
      ISZ=IIS
      IMSZ=IIMS
      CALL DAYMON(IID,IIH,IIM,IIS,IIMS)
C
CC    Find the number of pots
C
      CALL H2I(IM,31000,NP)
C
CC    Jump if FORTRAN write
C
      IF(IWRITE.EQ.1)GO TO 30
C
CC    Otherwise use multi-terminal output
C
      CALL SETTER(IUNIT,1)
      LEN=79
      IF(IUNIT.NE.4)GO TO 20
C
CC    Clear screen for terminal 4
C
      ICHAR=12
10    ITST=MTOUT(4,ICHAR)
      IF(ITST.EQ.1)GO TO 10
      ITICK=1                    !wait 1 tick for clear
      CALL ISLEEP(IZERO,IZERO,IZERO,ITICK)
C
CC    Write blank line
C
20    CALL SCOPY(BLANK,LINE)
      CALL MTPRNT(IUNIT,LINE)
C
CC    Write date and time line
C
      ENCODE(LEN,10030,LINE)IIH/3+1,IIM,IHZ,IMZ,ISZ,IMSZ
      CALL MTPRNT(IUNIT,LINE)
C
CC    Write blank line
C
      CALL SCOPY(BLANK,LINE)
      CALL MTPRNT(IUNIT,LINE)
C
CC    Write headings
C
      ENCODE(LEN,10040,LINE)
      CALL MTPRNT(IUNIT,LINE)
      ENCODE(LEN,10050,LINE)
      CALL MTPRNT(IUNIT,LINE)
      ENCODE(LEN,10060,LINE)
      CALL MTPRNT(IUNIT,LINE)
C
C     Write blank line
```

```
C
      CALL SCOPY(BLANK, LINE)
      CALL MTPRNT(IUNIT, LINE)
      GO TO 40                  ! Go to start of loop
C
C     FORTRAN write
C     First, write date and time line
C
30    IF(IUNIT.NE.6)WRITE(IUNIT, 10030, END=80, ERR=80)
     1                                  IIH/3+1, IIM, IHZ, IMZ, ISZ, IMSZ
      IF(IUNIT.EQ.6)WRITE(IUNIT, 10080) IIH/3+1, IIM, IHZ, IMZ, ISZ, IMSZ
C
C     Write blank line
C
      WRITE(IUNIT, 10010, END=80, ERR=80)
C
C     Write headings
C
      IF(IUNIT.NE.6)WRITE(IUNIT, 10040, END=80, ERR=80)
      IF(IUNIT.EQ.6)WRITE(IUNIT, 10090)
      IF(IUNIT.NE.6)WRITE(IUNIT, 10050, END=80, ERR=80)
      IF(IUNIT.EQ.6)WRITE(IUNIT, 10100)
      IF(IUNIT.NE.6)WRITE(IUNIT, 10060, END=80, ERR=80)
      IF(IUNIT.EQ.6)WRITE(IUNIT, 10110)
C
C     Write blank line
C
      WRITE(IUNIT, 10010, END=80, ERR=80)
C
C     Convert and output NP configurations
C
40    DO 70 I=1,NP
        LOCN=31002+(I-1)*8
        CALL H2I(IM, LOCN, NW)
        CALL H2I(IM, LOCN+2, NHC)
        CALL H2I(IM, LOCN+4, NG)
        CALL H2I(IM, LOCN+6, NDUM)
        DO 50 J=2,42,2
          CALL H2I(IM, 31498+J, NTST)
50        IF(NG.EQ.NTST)GO TO 60
60      NG=J*3-42
        IGPRE=(7-(NHC.AND."7))*6
        IATT=(7-(NHC.AND."70)/8)*6
        IHC=(NHC.AND."100)/64
        IHIO=(NHC.AND."200)/128
        IHD=(NDUM.AND."1)
        ILIO=(NDUM.AND."2)/2
        HC='HYD'
        IF(IHC.EQ.1)HC='CAL'
        HIO='OUT'
        IF(IHIO.EQ.1)HIO=' IN'
        HD='HYD'
        IF(IHD.EQ.1)HD='DUM'
        LIO=' IN'
        IF(ILIO.EQ.1)LIO='OUT'
        NGT=NG+IGPRE
        IF(IWRITE.EQ.0)ENCODE(LEN, 10070, LINE)
     1                    I, NW, IGPRE, NG, HIO, LIO, HC, HD, IATT, NGT, I
        IF(IWRITE.EQ.0)CALL MTPRNT(IUNIT, LINE)
        IF((IWRITE.EQ.1).AND.(IUNIT.NE.6))WRITE(IUNIT, 10070, END=80,
     1          ERR=80)I, NW, IGPRE, NG, HIO, LIO, HC, HD, IATT, NGT, I
70      IF((IWRITE.EQ.1).AND.(IUNIT.EQ.6))WRITE(IUNIT, 10120)
```

```
     1                I, NW, IGPRE, NG, HIO, LIO, HC, HD, IATT, NGT, I
      IF(IWRITE.EQ.0)CALL SETTER(IUNIT,0)
      IF(IWRITE.EQ.0)RETURN
C
C     Write formfeed for printer
C
      IF(IUNIT.EQ.6)WRITE(IUNIT,10020)
      IF(IUNIT.NE.6)RETURN
C
C     Force printer to output buffer
C
      CLOSE(UNIT=IUNIT)
      OPEN(UNIT=IUNIT)
      RETURN
C
C     Error on write
C
80    STOP 'CHYDRA.LOG full.  Rename it,
      1 then RUN CHYDRA and Quit again.'
C
10010 FORMAT(1X)                ! blank line for write
10020 FORMAT('1')               ! formfeed for write
10030 FORMAT(' DATE: 83-',I2,'-',I2,',    TIME: ',I3,':',
      1I2,':',I2,'.',I3,',    CHYDRA version 83-5-16',5X)
10040 FORMAT(' POT WIRED PRE-AMP  PAD,G1,G2 HIPASS AALIAS HYD HYD
      1 ATTEN  TOTAL   POT')
10050 FORMAT('  #    #   GAIN(dB) GAIN(dB)  FILTER FILTER CAL DUM
      1  (dB) GAIN(dB)  # ')
10060 FORMAT('       [C]     [F]        [G]       [W]     [U]  [H] [I]
      1  [A]',14X)
10070 FORMAT(1X,I2,' ←',I3,' ←←←',I3,' ←←←←←',I4,' ←←←←← ',A3,' ←← ',
      1      A3,2X,A3,1X,A3,I4,' ←←←',I4,' ←←',I3)
C
C     Duplicate formats spaced over 11 spaces for printer
C
10080 FORMAT(/////12X,'DATE: 83-',I2,'-',I2,',    TIME: ',I3,':',
      1I2,':',I2,'.',I3,',    CHYDRA version 83-5-16')
10090 FORMAT(12X,'POT WIRED PRE-AMP  PAD,G1,G2 HIPASS AALIAS HYD HYD
      1 ATTEN  TOTAL   POT')
10100 FORMAT(12X,' #    #   GAIN(dB) GAIN(dB)  FILTER FILTER CAL DUM
      1  (dB) GAIN(dB)  #')
10110 FORMAT(12X,'      [C]     [F]        [G]       [W]     [U]  [H] [I]
      1  [A]')
10120 FORMAT(12X,I2,' ←',I3,' ←←←',I3,' ←←←←←',I4,' ←←←←← ',A3,' ←← ',
      1      A3,2X,A3,1X,A3,I4,' ←←←',I4,' ←←',I3)
      END
C-----------------------------------------------------DREA-SWA-STAAL----
      SUBROUTINE XMIT(IM)
C
C             This subroutine transmits the array configuration table
C     to the microprocessor, and tells it to set up the array.
C
      VIRTUAL IM(32000)
      BYTE IM,MSTART(7),ICHAR,ICHAR1,ICHAR2
C
      DATA MSTART/'!','M','0','2','8','0',' '/        !M0280
C
      IZERO=0
      CALL H2I(IM,31000,NP)    ! find the number of pots
      CALL SETTER(5,1)         ! open the link to the array
C
C     Load Hydra config. table into uProcessor, then check that
```

```
C       UT4 is still running.
C
        CALL LOAD(31000,31001+NP*8,MSTART,IM)
        IF(ICLEAR().NE.1)GO TO 90
C
C       Type $P0 <CR> to start control program, wait 43 ticks,
C       then error if second last returned character is not @.
C
        IF(IC2UP('$').NE.1)GO TO 90
        IF(IC2UP('P').NE.1)GO TO 90
        IF(IC2UP('0').NE.1)GO TO 90
        IF(IC2UP(13).NE.1)GO TO 90
        ITICK=43
        CALL ISLEEP(IZERO,IZERO,IZERO,ITICK)
        ICHAR1=0
10      IGOT1=MTIN(5,ICHAR)
        IF(IGOT1.EQ.1)GO TO 20
        ICHAR2=ICHAR1
        ICHAR1=ICHAR
        GO TO 10
20      IF(ICHAR2.EQ.'@')GO TO 30
        TYPE *,'*** CONTROL PROGRAM FAILED TO START IN XMIT ***'
        GO TO 90
C
C       Type Z <CR> to uProcessor to set up array, wait 30 ticks,
C       then error if a ? is returned or if second last returned
C       character is not @.
C
30      IF(IC2UP('Z').NE.1)GO TO 90
        IF(IC2UP(13).NE.1)GO TO 90
        ITICK=30
        CALL ISLEEP(IZERO,IZERO,IZERO,ITICK)
40      IGOT1=MTIN(5,ICHAR)
        IF(IGOT1.EQ.1)GO TO 50
        IF(ICHAR.EQ.'?')GO TO 80
        ICHAR2=ICHAR1
        ICHAR1=ICHAR
        GO TO 40
50      IF(ICHAR2.EQ.'@')GO TO 60
        TYPE *,'*** CONTROL PROGRAM QUIT IN XMIT ***'
        GO TO 90
C
C       Type U to uProcessor, wait 10 ticks, type <CR>
C       to get uP back to UT4 monitor
C
60      IF(IC2UP('U').NE.1)GO TO 90
        ITICK=10
        CALL ISLEEP(IZERO,IZERO,IZERO,ITICK)
70      IGOT1=MTIN(5,ICHAR)
        IF(IGOT1.EQ.0)GO TO 70
        IT=IC2UP(13)
        IM(31600)=0                     ! No changes to xmit
        CALL OUTCFG(IM,4,0)             ! Output config. to TT4:
        GO TO 90
C
C       Type error if Z command doesn't work
C
80      TYPE *,'*** Z UNRECOGNIZED BY CONTROL PROGRAM IN XMIT ***'
90      CALL SETTER(5,0)                ! reset command link to array
        RETURN
C-------------------------------------------------------DREA-SWA-STAAL----
        END
```

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13. ABSTRACT

This document describes the software used to control the underwater acoustic array Hydra. The Hydra array was developed at Defence Research Establishment Atlantic (DREA) for bottom mounted use in continental shelf waters. The array is controlled from a minicomputer on board ship, and through a microprocessor in the array. Both the minicomputer software and the microprocessor software are described.

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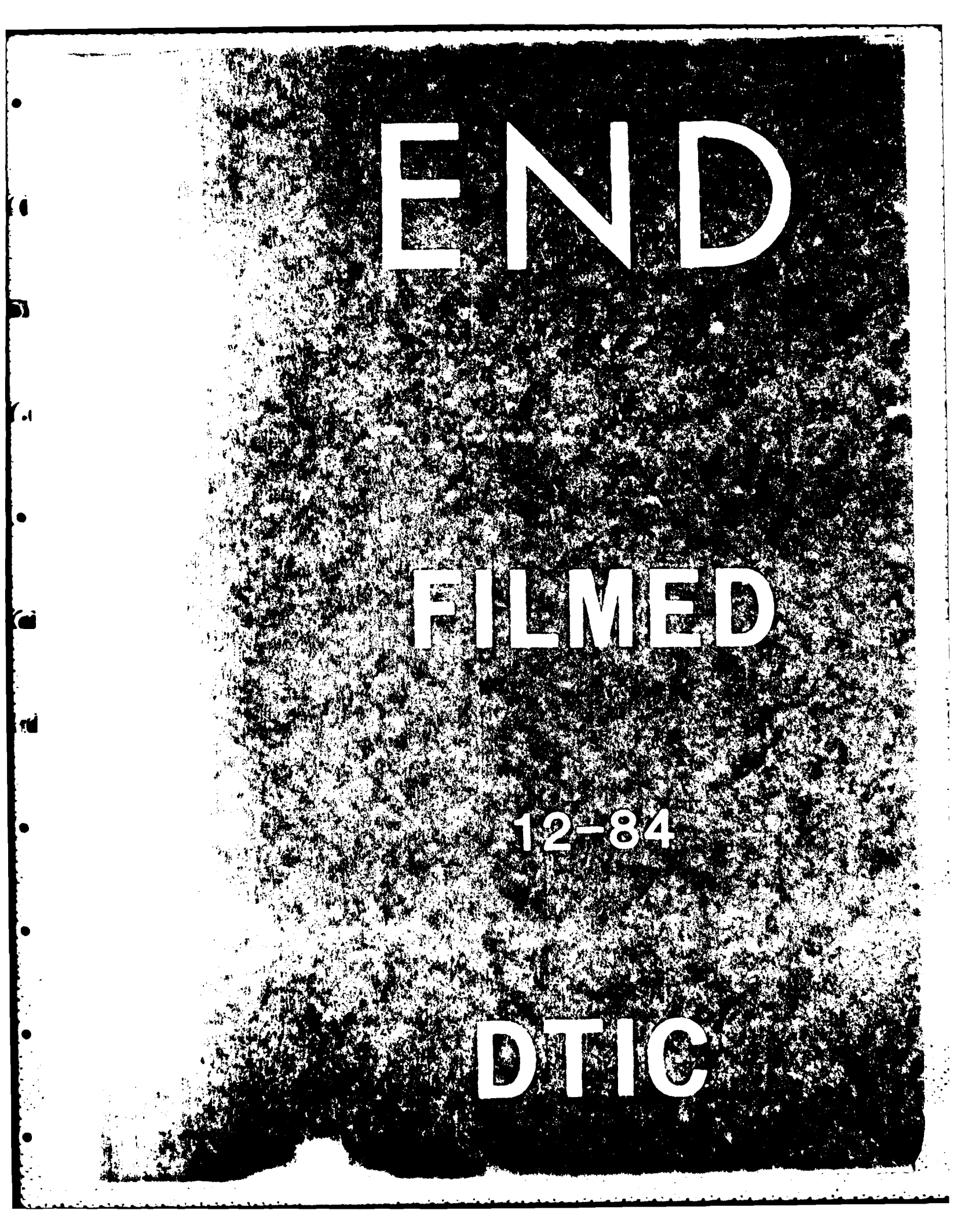
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